ROAD RAM USER MANUAL | FINAL NOVEMBER 2010

Tool prepared for use by: Lake Tahoe Stormwater Community and Environmental Improvement Program (EIP)

LAKE TAHOE ★ ROAD TO CLARITY

ROAD RAPID ASSESSMENT METHODOLOGY (ROAD RAM)

Environmental Incentives

2NDNATURE ecosystem science + design

nhc

Road Rapid Assessment Methodology (Road RAM)

Road RAM User Manual
Final November 2010

The Road RAM development is part of a multi-stakeholder collaborative effort to minimize the deleterious effects of urban stormwater on the ecosystem and economy of the Lake Tahoe Basin. This product would not be possible without the generous participation of several Basin regulatory and project implementing entities.

Prepared for:

Prepared by:

Recommended citation:
2NDNATURE LLC et al. 2010. Road Rapid Assessment Methodology (Road RAM) User Manual, Tahoe Basin. Final Document. Prepared for the California Tahoe Conservancy and Nevada Division of Environmental Protection. November 2010.

Any questions regarding the Road RAM tool or associated protocols should be directed to the Database Administrator. Contact information is available on the website (www.tahoeroadram.com). Additionally, there is a technical support forum at http://environmentalincentives.centraldesktop.com/supportservicesforum/.

With great appreciation to our Technical Advisory Committee

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EXECUTIVE SUMMARY

The **Road Rapid Assessment Methodology (Road RAM)** is a set of quick and simple field observations that, when coupled with its complimentary web-based data management tool, assists Tahoe Basin natural resource managers in determining **road condition**[1] with respect to the downslope water quality risk. RAM field observations are based on scientific and engineering analysis, informed by rigorous monitoring and sampling across Tahoe Basin roads and correlated to the concentration of fine sediment particles (**FSP**; particles <16µm in diameter) generated from a road segment. Results of the Road RAM help inform maintenance needs, track condition over time and convey progress towards meeting stormwater program goals.

BACKGROUND

Fine sediment particles (FSP) have been identified as the priority **pollutant of concern** affecting lake clarity by the Lake Tahoe Total Maximum Daily Load (TMDL) (LRWQCB and NDEP 2010). Additional research has shown that roads are the greatest potential source of this pollutant.

Thousands of cubic yards of anthropogenic road abrasives are applied each year to Tahoe Basin roads to ensure winter driver safety. The pulverization over time of these abrasives and other material on the road surface by vehicles combine to generate FSP on Tahoe Basin roads. In order to protect stormwater quality from roadway pollutants, a variety of road improvement projects, ordinances and road maintenance practices are implemented. On-going road maintenance practices include strategies to reduce the amount of abrasives applied and continued road sweeping efforts to recover the pollutants on the road surface prior to a subsequent rain event. The balance of pollutant sources and sinks determine the condition of a road, and condition varies over time and across roads within the Tahoe Basin.

The Road RAM observations are conducted on a **road segment** on any particular day and used to generate a **road segment score** that expresses relative road condition on a scale ranging from 0 (worst) to 5 (best). The road segment score is correlated to a FSP concentration expected from that road segment should a runoff event occur. Classification of roads by the user allows the simple extrapolation of road segment scores to a **Road RAM score** for all roads within a designated area of interest using **road class**. The Road RAM scores can be used to track the condition of roads throughout the Tahoe Basin over time and compare actual observed road conditions to the expected road conditions predicted from the **Pollutant Load Reduction Model (PLRM)**. The RAM score generation, tracking over time and map generation are automated tasks as a result of consistent data management and functionality of the custom *Road RAM Database* (**database**) version 1. The Road RAM results across different roads will inform future improvements in design and maintenance strategies on Tahoe Basin roads to minimize the potential water quality impacts.

ROAD RAM IMPLEMENTATION

The Road RAM consists of a series of six STEPs that have been designed for ease and practicality from the user's perspective (Table ES.1). The user sequentially collects attribute data within the area of interest and populates the database (www.tahoeroadram.com). Road RAM STEPs 1, 2 and 3 are completed one time prior to conducting field observations at road segments. Road RAM STEPs 4-6 are repeated as often as RAM scores are desired.

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[1] **Bolded** terms are defined in *User Manual Part VI: Acronyms and Glossary.*

Table ES.1 Summary of Road RAM STEPs implemented by the user.

Road RAM STEP #	Road RAM STEP Name
1	Define AREA of interest
2	Create INVENTORY of road attributes
3	CLASSIFY roads
4A 4B	Select ROAD SEGMENTS Conduct FIELD OBSERVATIONS
5	Obtain Road RAM SCORE
6	ANALYZE results

Road RAM STEP 1 – Define AREA of interest

Users define the spatial area of interest within which to complete the Road RAM. This could include a single catchment, an entire jurisdiction, or any other area as defined by the user. The product of Road RAM STEP 1 is the delineation of the area of interest and each user may have multiple areas defined within the Road RAM tool. Ideally, the boundaries of areas do not have overlap. Jurisdictions will want to use the same catchment boundaries as registered with the Crediting Program.

Road RAM STEP 2 – Create INVENTORY of road attributes

The user creates a spatial **inventory** of the roads within the STEP 1 area of interest using an existing road GIS layer. Depending on the user's analysis goals, the roads can be categorized based on a variety of **road attributes** that are expected to vary across the area of interest. Typical attributes in Tahoe Basin include **PLRM road risk**, **road shoulder condition**, **road surface integrity**, **road shoulder connectivity**, etc. The product of Road RAM STEP 2 is one or more GIS layers of the road attributes within the area of interest defined in STEP 1.

Road RAM STEP 3 – CLASSIFY roads

Road RAM STEP 3 is the grouping of roads within the area of interest by similar road maintenance practices as conducted by the local jurisdiction. Road maintenance practices must be consistently defined by the **abrasive application priority, sweeping effectiveness**, and any other pollutant control practices that are expected to have a significant effect on the resulting road condition. Abrasive application priority and sweeping effectiveness are the most likely priority pollutant sources and sinks that influence on-going road maintenance practices, but jurisdictions have flexibility to define the combined road maintenance practices for each class. Road RAM STEP 3 product is a road class map which categorizes all roads into one of 9 potential road classes and used to by Road RAM to spatially extrapolate discrete field observations to the network defined in STEP 1.

Road RAM STEP 4 – Select ROAD SEGMENTS (4A) and Conduct FIELD OBSERVATIONS (4B)

The evaluation and tracking of Road RAM scores on roads is based on a set of standardized, repeatable and rapid **field observations** conducted on a series of road segments. Road segments are 10,000ft^2 locations selected by the user based on road class and are chosen prior to going into the field. Road RAM field observations take two trained field personnel approximately 10 minutes per road segment and include both visual observations and measurements that are proxies to predict the FSP concentration of the road segment. Typically a user conducts field observations on multiple road segments over 3-5 days, termed an **observation period**. STEP 4 can be repeated as frequently as desired and results in discrete records of actual observed road conditions that are tracked over time. Standardized user data entry forms facilitate consistent data input into the database. Figure ES.1 illustrates how a road segment is a spatially discrete point within a road network of interest.

Road Segment:
An area of road that can be reasonably evaluated by a single set of rapid Road RAM field observations. Each road segment where field observations are conducted is represented by a point in the database and the observed condition is expressed as a Road Segment Score, ranging from 0-5. In this example, the road segment score is 2.5.

Road Class:
A grouping of road segments that share similar fine sediment sources and sinks. All roads of the same road class are expected to be in similar condition on any given day. The Road RAM Score is an average of all segment scores within the road class. In this example all yellow segments in the diagram belong to the same road class and have a RAM score of 3.2.

Figure ES.1. Visual summary of key Road RAM concepts.

Road RAM STEP 5 – Obtain Road RAM SCORE

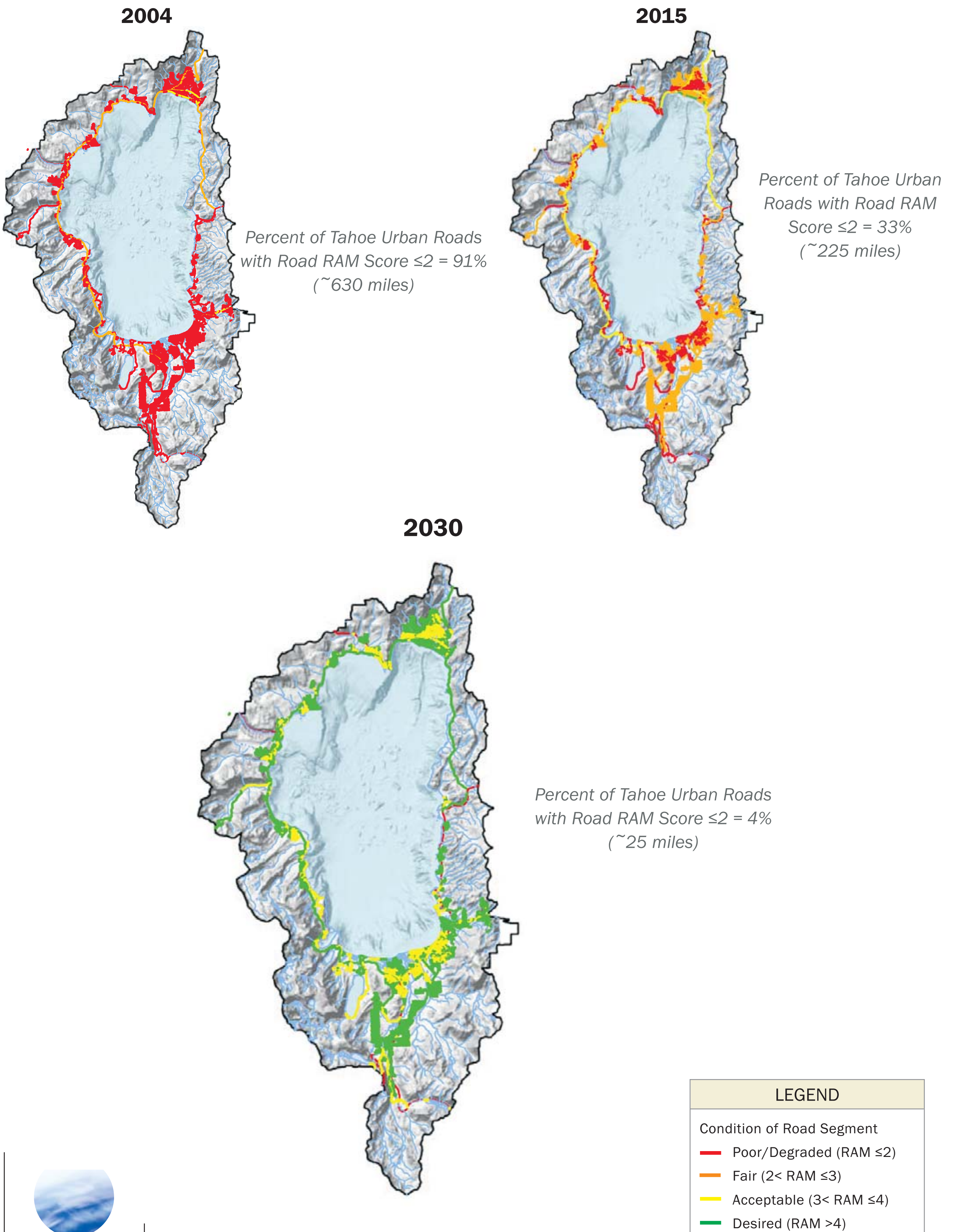
After entering field observation data into the database, the resulting RAM score is used to express road condition using a continuous 0-5 scale where 0 indicates poor road condition and a high risk to downslope water quality, and 5 is the best possible condition with minimal immediate water quality risk downslope (Table ES.2). The field observation data is used to calculate road segment scores that can be spatially extrapolated by road class to obtain Road RAM scores for all roads within the area of interest (see Figure ES.1). Road RAM results are displayed spatially using a color gradation from red to green for simple communication of actual conditions.

Table ES.2 Road RAM scores relative to road condition and relative risk to downslope water quality.

Road RAM Score	Condition	FSP Concentration (mg/L) range	• Description
0 - 1.0	Poor	1,592-680	• Significant potential risk to downslope water quality should runoff event occur • Road maintenance practices require immediate improvements • Capital improvement projects downslope may need to be considered to capture road generated pollutants
>1.0 - ≤ 2.0	Degraded	679-291	• Likely potential risks to downslope water quality • Road maintenance practices require immediate improvements • Capital improvement projects downslope may need to be considered to capture road generated pollutants
> 2.0 - ≤ 3.0	Fair	290-124	• Road condition is closer to degraded than desired, may pose downstream water quality risk • Road maintenance should be prioritized as needed if time and resources permit
> 3.0 - ≤ 4.0	Acceptable	123-53	• No immediate risk to downslope water quality should runoff event occur • Minimal need to improve road maintenance practices
> 4.0 – 5.0	Desired	52-23	• Maximum achievable road condition • No need to improve road maintenance practices

Road RAM STEP 6 – ANALYZE results

The Road RAM tool establishes a standardized methodology for evaluating the road condition and can be used to track and inform changes in road condition over time (Figure ES.2). These changes can be used to prioritize future water quality improvement actions, improve the scientific basis for numerous Tahoe stormwater tools, evaluate the performance of various road maintenance practices, and address other gaps in our knowledge of pollutant generation and transport from this priority land use. Moreover, Road RAM results can be used to document actual annual road conditions and verify the expected conditions used in other Tahoe stormwater tools.



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HYPOTHETICAL PROGRESSION OF TAHOE BASIN ROAD CONDITION OVER TIME

FIGURE ES.2

PART 0: ROAD RAM TOOL ORIENTATION

USER MANUAL OVERVIEW

The *Road RAM User Manual* contains the following parts:

- *Part 0: Road RAM Tool Orientation* provides a quick orientation to the User Manual document, the Road RAM STEPs, and the database located at www.tahoeroadram.com and its functions.
- *Part I: Road RAM Protocols* describes the required data collection, management and analysis protocols for each of the six Road RAM STEPs. Part I is primarily targeted to the personnel who are expected to implement the Road RAM observations over time. Part I includes an overview, describing the purpose and process of the step; the protocols each user must follow to complete the step; and additional guidance on Road RAM protocols, as necessary.
- *Part II: Alignment with Crediting Program* provides further considerations for the user, beyond the minimum requirements to implement Road RAM. Part II discusses the necessary steps in order to use Road RAM in conjunction with the Lake Clarity Crediting Program (Crediting Program).
- *Part III: GIS Commands* details the protocols for the GIS commands that are repeated throughout STEPs 1-4. The commands provided in Part III are *italicized* in *Part I: Road Ram Protocols*.
- *Part IV: Troubleshooting* includes tips and advice for the user on common errors associated with implementing Road RAM.
- *Part V: Field Protocols and Datasheets* is a stand-alone attachment of the STEP 4B field protocols and accompanying datasheet for use by field personnel.
- *Part VI: Acronyms and Glossary* includes definitions for the key terms used throughout the User Manual.
- *Appendix A: Training Example* provides example products of the Road RAM for a hypothetical project area in the Lake Tahoe Basin. The Road RAM database has been populated with hypothetical data for the test area to provide a tangible example for the new Road RAM user. The sample data used to populate the database is available for download from the database (see "Downloads" on the website banner).

Throughout the document screenshots of the database are used to orient the user. All required formatting, entry and content rules are highlighted in blue text boxes to ensure data and referential integrity within the database.

RULES
- **Data requirements are highlighted to ensure proper Road RAM Database use.**

There are many aspects of the Road RAM that can be implemented in coordination with the Crediting Program. *Part II: Alignment with Crediting Program* directly addresses many of the opportunities to align Road RAM results with the Crediting Program requirements. If there are specific recommendations for implementation of Road RAM protocols, those are highlighted in green text boxes (example shown on right) within the relevant *Part I: Road RAM Protocols* section.

Crediting Program
- **Opportunities to align Road RAM protocols with the Crediting Program are highlighted.**

All questions concerning the use of the database should be directed to the Database Administrator. Contact information is available on the home page of the website (www.tahoeroadram.com).

ROAD RAM STEP OVERVIEW

The *Road RAM User Manual* guides the user through data generation, management and analysis for each of the Road RAM STEPs outlined in Table 0.1. The Road RAM user gathers data, performs spatial analyses, enters data into the Road RAM online database (www.tahoeroadram.com), and then extracts spatial (Google Map®) and tabular (Excel, Word, csv) results from the database. The user should be familiar with the terminology and concepts outlined in the *Road RAM Technical Document* prior to implementing Road RAM STEPs. The *Part VI: Acronyms and Glossary* is provided for easy reference of key terms.

The Road RAM tool integrates GIS analysis and field observations with an online database, Google Maps® display, and tabular exports. Table 0.1 provides an overview of the GIS analysis and database interaction associated with each Road RAM STEP, as well as the typical frequency at which the step is performed and the likely user type. Road RAM results can be generated for spatially discrete road segments and/or extrapolated to include all roads within an area of interest. Figure 0.1 indicates the necessary Road RAM STEPs performed by the user, depending on the desired Road RAM results.

Table 0.1. GIS analysis and database interaction by Road RAM STEP.

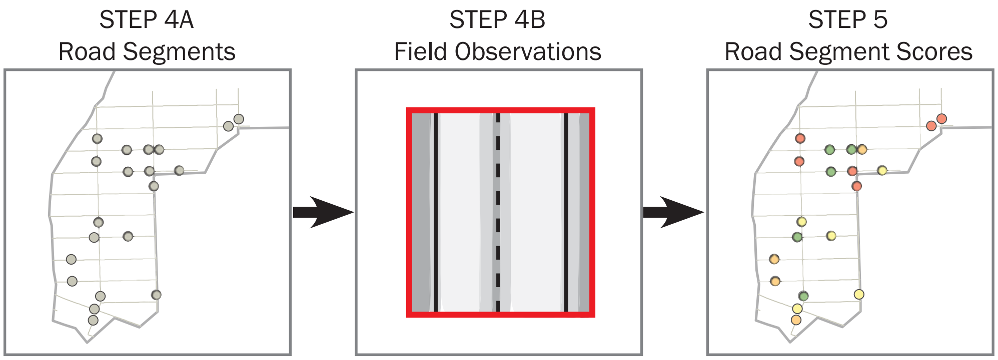
Road RAM STEP #	Road RAM STEP Name	GIS Analysis[1]	Online Database[2]	Frequency of STEP completion	Likely Users[3]
1	Define AREA of interest	Edit Export	Download Data Upload Data View Map	2-5 years	UJ
2	Create INVENTORY of road attributes	Copy Edit Split/Merge	Download Data	2-5 years	UJ
3	CLASSIFY roads	Copy Split/Merge Intersect Clip Export	Upload Data View Map View Query	2-5 years	UJ
4A	Select ROAD SEGMENTS	Edit Spatial Join Export	Download Data Upload Data View Map View Query	2-5 years	All
4B	Conduct FIELD OBSERVATIONS	n/a	Enter Data	Seasonally	All
5	Obtain Road RAM SCORE	n/a	View Map View Query	Seasonally	All
6	ANALYZE results	n/a	View Map View Query	Seasonally	All

[1] GIS spatial analysis command used in GIS during the corresponding Road RAM STEP. See *Part III: GIS Commands* for detailed description and user protocols.
[2] Type of database interaction: Uploaded data is added to the database via *.csv and *.kmz files; Downloaded data includes GIS templates and shapefiles; Entered data is input directly into the database using online forms; Maps are viewed in Google Maps; Queries can be exported to MS Excel or Word. Detailed protocols are provided in *Part I: Road RAM Protocols* for each STEP.
[3] Users include urban jurisdictions (UJ), regulators, scientific advisors, and grantors. Urban jurisdictions will have the most accurate information to correctly perform STEPs 1-3. See *Technical Document Chapter 3: Road RAM Programmatic Integration* for more details on user types.

It is important to note that while all users can perform all steps, certain users, such as urban jurisdictions, will have access to the most accurate information concerning road attributes and road maintenance practices.

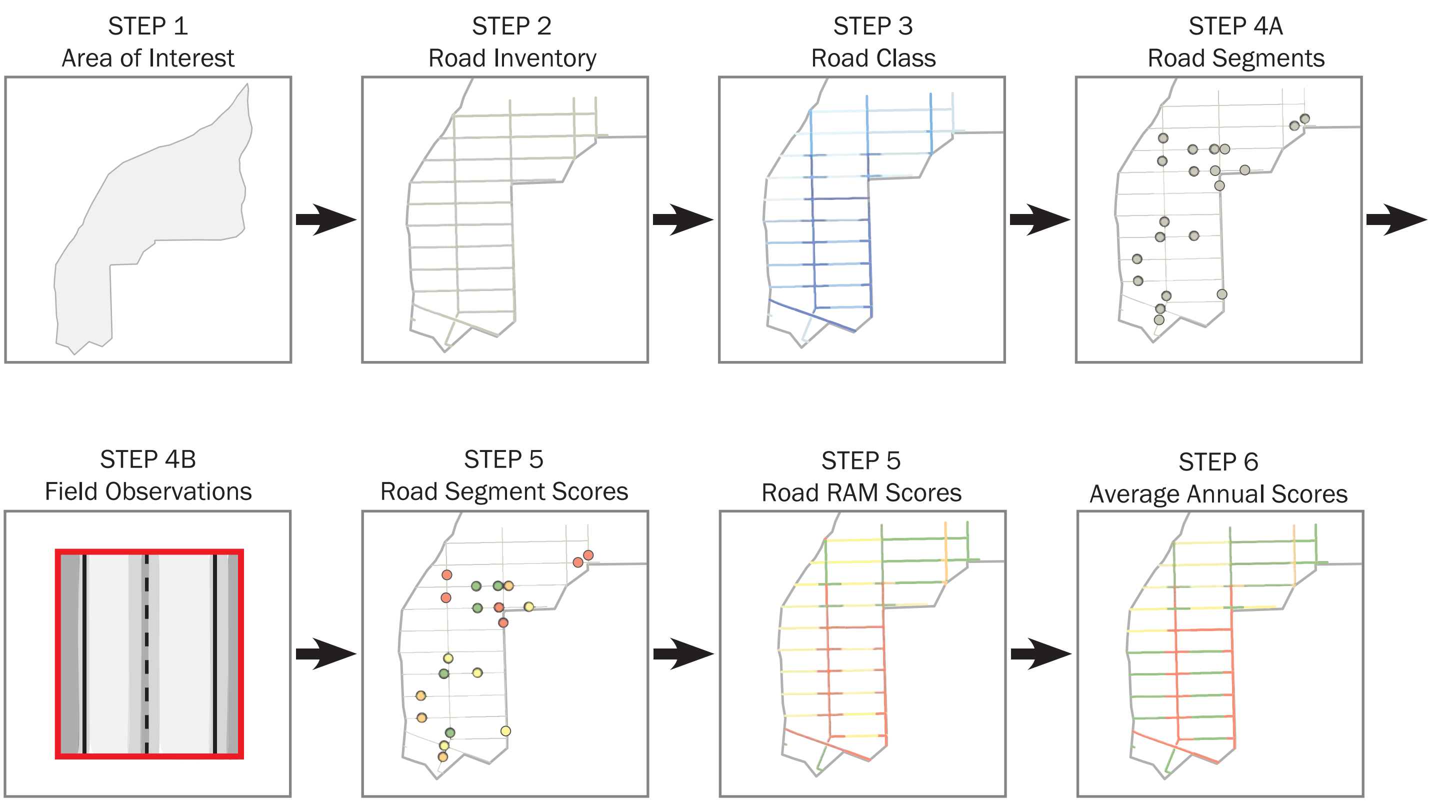
SPATIALLY DISCRETE RESULTS

- The user selects discrete locations (Step 4A) to perform field observations (STEP 4B) and tracks road condition of these specific sites over time (Step 5). The user performs Road RAM STEPs 4 and 5 only.



SPATIALLY EXTRAPOLATED RESULTS

- The user extrapolates the results of discrete field observations to a larger area of interest by classifying all roads within the area of interest based on road maintenance practices. The user performs all Road RAM STEPs.



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ROAD RAM STEP OVERVIEW

FIGURE 0.1

DATABASE OVERVIEW

Figure 0.2 is a screenshot of the banner on the Road RAM Database website (http://www.tahoeroadram.com). The user navigates through the database functions using this banner.

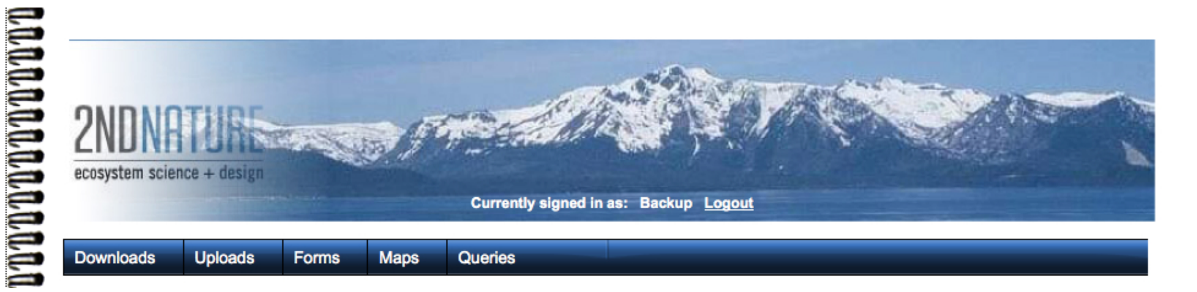


Figure 0.2. Road RAM Database Banner.
User navigates through database by clicking on Downloads, Uploads, Forms, Maps, and Queries.

The following provides a brief description of the functions:

- Downloads: Download files directly from the website to a computer, including the Road RAM Technical Document, User Manual, GIS template files, and sample data.
- Uploads: Import STEPs 1, 3 and 4A data into the database using *.csv and *.kmz files.
- Forms: Enter field observation data (STEP 4B) into the database using a custom data entry form.
- Maps: View the spatial results of STEPs 1, 3, 4, 5 and 6 using Google Maps.
- Queries: View the tabular results of STEPs 1, 3, 4, 5 and 6.

By clicking on the specific database function in the banner, the user can select the appropriate option within each function (Figure 0.3). Throughout the User Manual, these options are indicated with "->". For example, in Figure 0.3 the user is shown selecting "Downloads" -> "Road RAM User Manual v1."

Figure 0.3. Road RAM Database Navigation.
Here user is shown selecting the Road RAM User Manual to download.

All questions concerning the use of the Road RAM Database should be directed to the Database Administrator (contact information available at the login page on www.tahoeroadram.com). Note that while Road RAM is compatible with any standard internet browser, the tool was primarily tested using Mozilla Firefox.

PART I: ROAD RAM PROTOCOLS

DATABASE SETUP

OVERVIEW

The Road RAM database is a browser-based web application that can be accessed on any computer with an internet connection and standard browser (Internet Explorer 6+, Firefox, Safari, etc.). Note that while Road RAM is compatible with any standard internet browser, the tool was primarily tested using Mozilla Firefox.

PROTOCOLS

Time Required: 5 minutes

Equipment Required:

- Computer with internet connection

RULES

- **Each user name must be unique.**
- **Only the user who has uploaded and/or entered the data into the database has full access to edit and delete that data.**

SETUP AND LOGIN

1. Set up user name and password.
   Contact the Database Administrator to establish a user name, password, and appropriate database privileges. The Database Administrator contact information is available on the login page of the website.
2. Login to database.
   - o Navigate to www.tahoeroadram.com using an internet browser.
   - o Enter User Name and Password (Figure 1.1).
   - o Click "Click to Login."

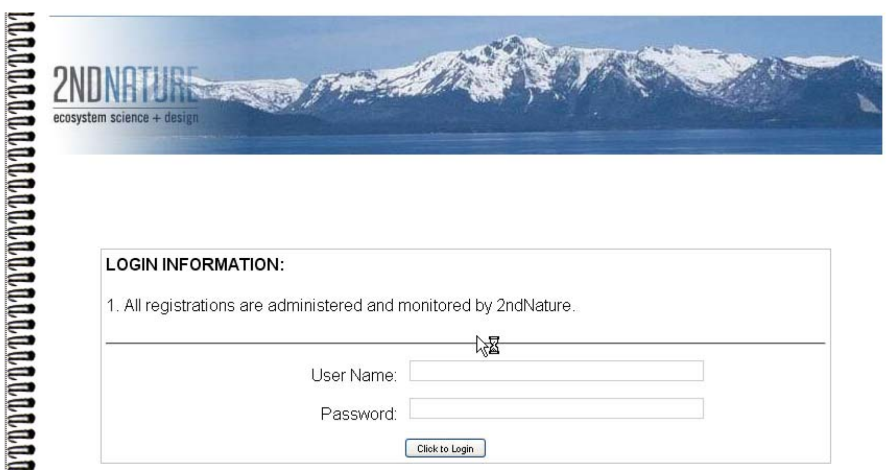


Figure 1.1. Road RAM Database Login Page (www.tahoeroadram.com).

   - o You will be directed to the Tahoe Road RAM database (Figure 1.2) and shown as logged in under the correct User Name. See *Part IV: Troubleshooting - Database Setup* for the resolution of common database login issues.

Figure 1.2. Logged-in Road RAM Database user.
Currently logged in as (User Name): "Backup".

3. Log out of database.
   - In the website banner, click "Logout" (see Figure 1.2).

ADDITIONAL GUIDANCE

DATA ACCESS

The Road RAM database security is established such that only the user who has uploaded and/or entered data into the database has full access to edit and delete that data. Therefore it is recommended that an entity (i.e., urban jurisdiction, regulatory agency, scientific organization, etc.) establishes only one user name and password for use by all of its members that will interact with the database. If, however, an entity wishes to have added data management security within its organization, please contact the Database Administrator (contact information available on the website).

ROAD RAM STEP 1 – DEFINE AREA OF INTEREST

STEP 1 OVERVIEW

The user spatially defines the area of interest in GIS, assigns the area a unique ID, and uploads the data to the database (Table 1.1). The STEP 1 outputs are a spatial display of the area of interest and a populated Road RAM Database.

Table 1.1. GIS analysis and database interaction for Road RAM STEP 1.

Road RAM STEP #	Road RAM STEP Name	GIS Analysis	Online Database	Frequency of STEP completion
1	Define AREA of interest	Edit Export	Download Data Upload Data View Map	2-5 years

The main purpose of STEP 1 is to define the spatial extent for STEPs 2 and 3 and allow for spatial extrapolation of Road RAM scores obtained for a series of discrete segments. If the user intends only to track the condition of spatially-discrete road segments over time (i.e., will not spatially extrapolate road segment results to road class), STEP 1 is not necessary (see Figure 0.1).

PROTOCOLS

Time Required: 1.5 – 3 hours, depending on total acreage of area of interest

Equipment and Expertise Required:

- Computer with ArcGIS 9 and internet connection
- Familiarity with ArcGIS 9

Note: Italicized words indicate GIS commands detailed in *Part III: GIS Commands*.

DOWNLOAD TEMPLATE FROM DATABASE

1. Download STEP 1 template zip file from the database.
    a. Go to “Downloads” -> “Shapefiles” ->“RoadRAM_STEP1template.shp.zip”.
    b. Rename file and save to computer. Suggested naming convention for shapefile is STEP1_AreaYear[2].
    c. Click “Parent Directory” to return to the home screen.

GIS PROCEDURES

1. In ArcGIS*, edit feature* to delineate area of interest.
2. *Edit fields in attribute table*.
   ID: Use *Field Calculator* to have ID equal FID field.
   Area: unique name for area of interest.
   AreaDesc: description of the area of interest.
   AreaArea: Use *Calculate Geomet*ry to calculate the area in acres.
3. *Export attribute table as *.txt file,* where suggested naming convention is STEP1_ AreaYear[2].
4. *Export shapefile to *.kmz*, where suggested naming convention is STEP1_AreaYear[2].

RULES

- **The name of the area of interest must be unique.**
- **Boundaries of individual areas of interest should not intersect or overlap another area of interest.**
- **Adjacent areas share boundaries; there are no overlaps or gaps between boundary lines.**

[2] Where “Area” is a unique name for the area of interest and “Year” is the year when the area was delineated.

UPLOAD TO DATABASE

1. Import attribute table from Excel into database.
    a. Convert exported *.txt file to *.csv file using Microsoft Excel. Figure 1.3 shows the proper formatting for the *.csv file, including required headers and fields.

	A	B	C	D	E
1	FID_	ID	Area	AreaDesc	AreaArea
2	0	0	WC1_B	Washoe County	62.746763
3					

Figure 1.3. Proper formatting for STEP 1 *.csv file. Column headers (bolded in row 1) must be formatted as shown. “ID”, “Area”, and “AreaArea” must have values in the fields (Row 2). FID_ and AreaDesc can be blank, as shown.

    b. Go to “Uploads” -> “CSV Uploads.”
    c. Select “Step 1- Catchment” table to receive the data (Figure 1.4).
    d. Browse for appropriate *.csv file.
    e. Click “Process.” See *Part IV: Troubleshooting* for guidance on common importing errors.

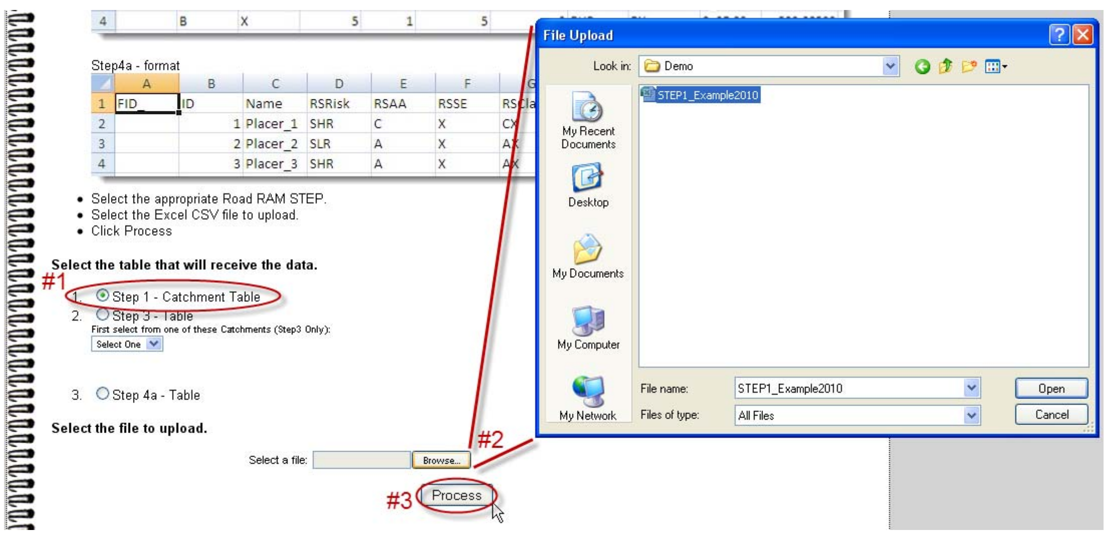


Figure 1.4. STEP 1 *.csv Upload.

RULE

- **The attribute table (*.csv) must be uploaded to the database first, then the corresponding shapefile (*.kmz).**

2. Import *.kmz shapefile into database.
    a. Go to “Uploads” -> “KMZ Uploads.”
    b. Select “(kmz) Catchment File” table to receive the data (Figure 1.5).
    c. Select the appropriate area of interest from the drop down menu (see Figure 1.5).
    d. Browse for appropriate *.kmz file.
    e. Click “Process.” See *Part IV: Troubleshooting – Database Upload* for guidance on common importing errors.

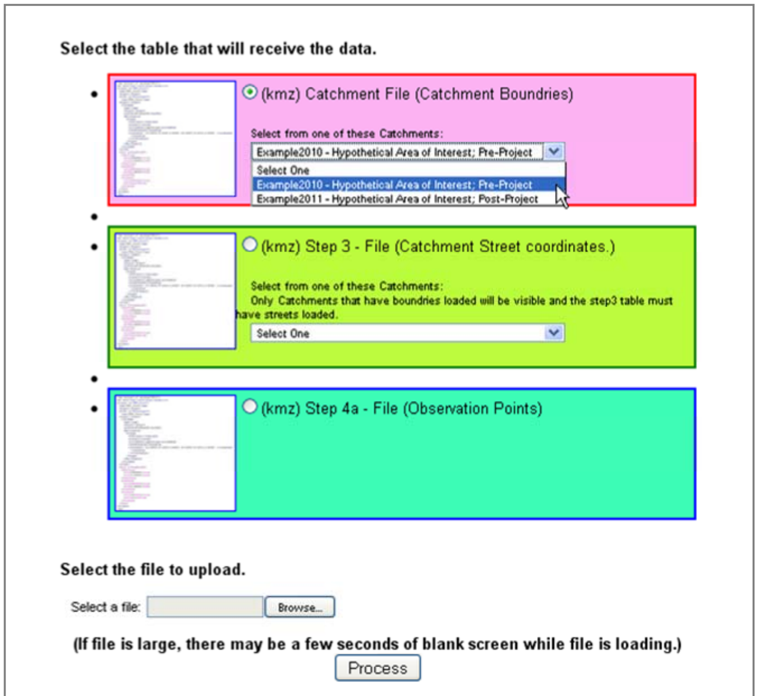
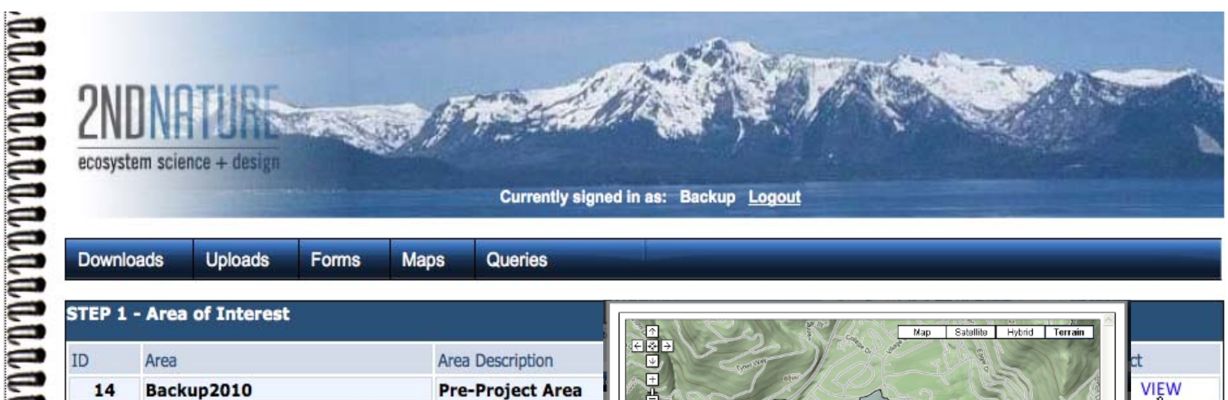


Figure 1.5. STEP 1 *.kmz Upload.

3. View Area of Interest Map to verify upload.
   a. Go to "Maps" -> "STEP 1 Area of Interest."
   b. Locate appropriate area of interest (Figure 1.6) and select map icon on right for the specific area of interest to view map and verify delineation.



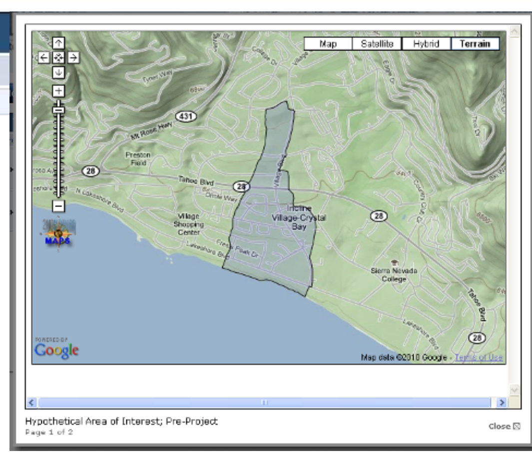


Figure 1.6. View STEP 1 Map.
Clicking on "View" hyperlink at right will produce a Google Map pop up of the area of interest (shown at right).

ADDITIONAL STEP 1 GUIDANCE

CONSIDERATIONS FOR DEFINING AREAS OF INTEREST

Road maintenance practices and other road attributes are most efficiently defined on a jurisdiction-wide scale. Jurisdictions should define their STEP 1 area of interest as the complete urban jurisdiction, create the STEPs 2 and 3 road attribute shapefiles to include all roads within the jurisdiction, and select STEP 4A road segments that are spatially distributed throughout their jurisdiction. If the jurisdiction wishes to define a smaller area of interest (e.g., an urban planning catchment) to maintain consistency with other Lake Tahoe stormwater tools (Pollutant Load Reduction Model [PLRM], **Best Management Practice Maintenance Rapid Assessment Methodology [BMP RAM]**, etc.), then the jurisdiction-wide shapefiles can be clipped using the smaller STEP 1 area of interest. This process is described in Figure 1.7 and will reduce the overall level of effort while ensuring Road RAM results are accurate.

UPDATING STEP 1 DATA

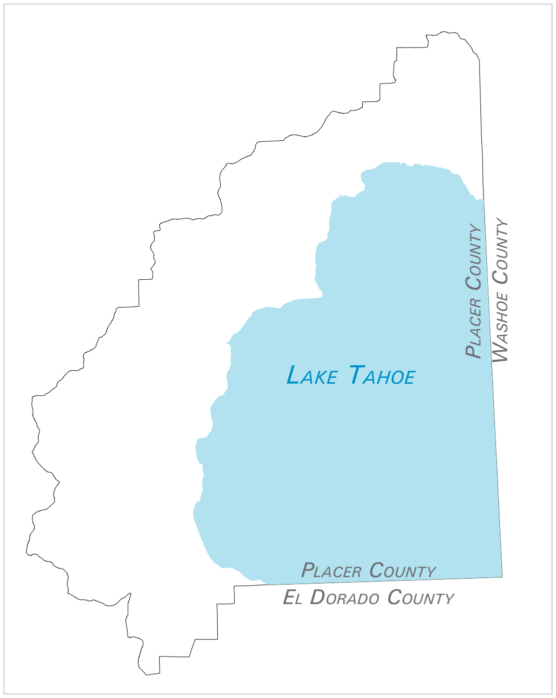
The process for updating STEP 1 data is presented in Figure 1.8. In the event that STEP 1 data needs to be updated, it is likely for one of three reasons: (1) there is a correction to the initial delineation (Figure 1.8A), (2) the boundaries of an area of interest have changed over time (Figure 1.8C), or (3) the roads (actual roads or the categorization of existing roads) within the catchment have changed significantly (Figure 1.8D, E).

RULES

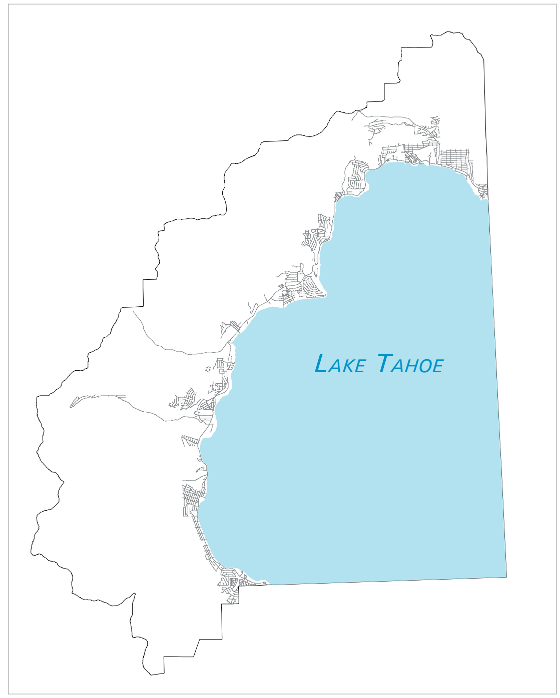
- **If a *.csv or *.kmz file is uploaded with the same STEP 1 "Area" value as an existing database entry, the existing file is overwritten and the previous information is deleted.**

DEFINING AREAS OF INTEREST

A. Determine largest area of interest (e.g., Jurisdiction). Complete STEP 1.

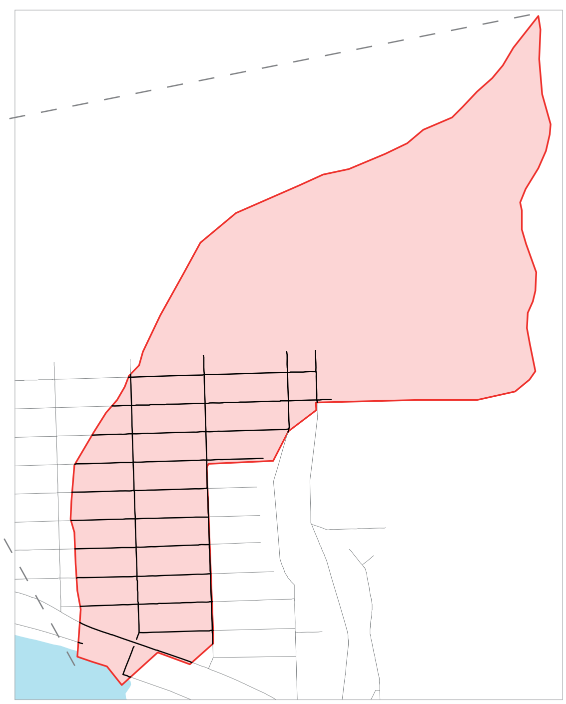


B. Inventory and classify roads within area. Complete STEPs 2, 3 and 4A.



C. Delineate smaller areas of interest (e.g, UPCs). Complete STEP 1.

D. Clip larger STEP3 product by smaller STEP 1 areas. Complete STEP 3 upload.



Note: Catchment boundaries do not overlap or intersect one another and are located wholly within the area of interest defined in A.

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PROCESS TO UPDATE ROAD RAM DATA

A. OVERWRITE AND/OR ADD TO EXISTING DATA (STEPS 1 AND 4A)

Existing data in database is replaced with updated information.
Keep existing unique value(s) in database.
Refer to *User Manual Part I: Road RAM Protoocols* for detailed protocols associated with each bullet.

STEP 1
- Keep existing "Area" value.
- Edit feature and/or fields.
- Calculate geometry.
- Export and upload.

if STEP 3 has already been completed

STEP 3
- Clip feature.
- Export and upload to existing "Area" value.

STEP 4A
- Keep existing "Name" value (if adding locations, create new unique value).
- Edit feature.
- Export and upload.

B. OVERWRITE EXISTING DATA (STEPS 2 AND 3)

Existing data in database is replaced with updated information.
Keep existing unique value(s) in database.
Refer to *User Manual Part I: Road RAM Protoocols* for detailed protocols associated with each bullet.

STEPs 2/3
- Edit features and/or fields.
- Intersect features.
- Export and upload to existing "Area" value.

if STEP 4A has already been completed

STEP 4A
- Spatial join.
- Export and upload using existing "Name" values.

C. CHANGE AREA OF INTEREST BOUNDARY (STEP 1)

Existing information is kept in database.
User creates new database record with new unique value.
Refer to *User Manual Part I: Road RAM Protoocols* for detailed protocols associated with each bullet.

STEP 1
- Create new shapefile with new "Area" value[1].
- Follow *Part I: Road RAM Protocols*.

STEP 3
- Clip feature.
- Export and upload to new "Area" value.

LEGEND

- STEP 1 update
- STEP 2/3 update
- STEP 4A update
- Required action
- Perform as necessary

[1] *Suggested naming convention is to update the year value following the recommended naming convention, where year is when the changes were implemented.*

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PROCESS TO UPDATE ROAD RAM DATA (continued)

D. CHANGES IN ROAD ATTRIBUTES OVER TIME (STEPS 2 AND 3)

Existing information is kept in database.
User creates new database record with new unique value(s).
Refer to *User Manual Part I: Road RAM Protoocols* for detailed protocols associated with each bullet.

STEP 1

- Copy existing shapefile and rename with new “Area” value[1].
- Follow *Part I: Road RAM Protocols*.

→

STEPs 2/3

- Edit features and/or fields.
- Intersect features.
- Export and upload to new “Area” value.

→

STEP 4A

- Copy existing shapefile and rename with new “Name” value[1].
- Spatial join.
- Export and upload with new “Name” values.

E. CHANGES IN ROAD BASELAYER (STEP 2)

Existing information is kept in database.
User creates new database record with new unique value(s).
Refer to *User Manual Part I: Road RAM Protoocols* for detailed protocols associated with each bullet.

STEP 1

- Copy existing shapefile and rename with new “Area” value[1].
- Follow *Part I: Road RAM Protocols*.

→

STEPs 2 and 3

- Copy baselayer and rename with new “Area” value.
- Edit features in baselayer.
- Copy updated baselayer to create new STEP 2 and 3 attribute layers.
- Merge/split features.
- Edit fields.
- Intersect features.
- Export and upload to new “Area” value.

→

STEP 4A

- Copy existing shapefile and rename with new “Name” value[1].
- Spatial join.
- Export and upload with new “Name” values.

LEGEND

- STEP 1 update
- STEP 2/3 update
- STEP 4A update
- Required action
- Perform as necessary

[1]Suggested naming convention is to update the year value following the recommended naming convention, where year is when the changes were implemented.

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FIGURE 1.8

ROAD RAM STEP 2 – CREATE INVENTORY OF ROAD ATTRIBUTES

STEP 2 OVERVIEW

The user creates a spatial inventory of the roads within the area of interest defined in STEP 1 (Table 1.2). The inventory mapping may include a range of optional road attributes, such as road risk category (PLRM), road surface integrity, road shoulder condition, and road shoulder connectivity. STEP 2 is conducted entirely in GIS and there are no inputs to the database during STEP 2. There are also no database outputs as the STEP 2 products are maintained in GIS. Figure 1.9 illustrates the flow of data collection and spatial analysis for STEPs 2 and 3. STEP 2 includes the creation of the required road inventory baselayer, as well as additional optional road attribute shapefiles.

Table 1.2. GIS analysis and database interaction for Road RAM STEP 2.

Road RAM STEP #	Road RAM STEP Name	GIS Analysis	Online Database	Frequency of STEP completion
2	Create INVENTORY of Road Attributes	Copy Edit Split/Merge	n/a	2-5 years

The main purpose of STEP 2 is to create the road inventory of specific attributes of interest. The attributes related to road maintenance sources and sinks are identified in STEP 3: Classify Roads and allow for spatial extrapolation of Road RAM scores obtained for a series of discrete segments. If the user intends only to track the condition of spatially-discrete road segments over time (i.e., will not spatially extrapolate road segment results to road class), STEP 2 is not necessary (see Figure 0.1).

PROTOCOLS

Time Required: 2-4 hours, depending on the total acreage of area of interest

Equipment and Expertise Required:

Computer with ArcGIS 9

Familiarity with ArcGIS 9

Note: Italicized words indicate GIS commands detailed in the *Part III: GIS Commands*.

RULES

- **Users must use the Road RAM inventory shapefile.**
- **Do not delete any feature within the STEP 2 road shapefiles.**

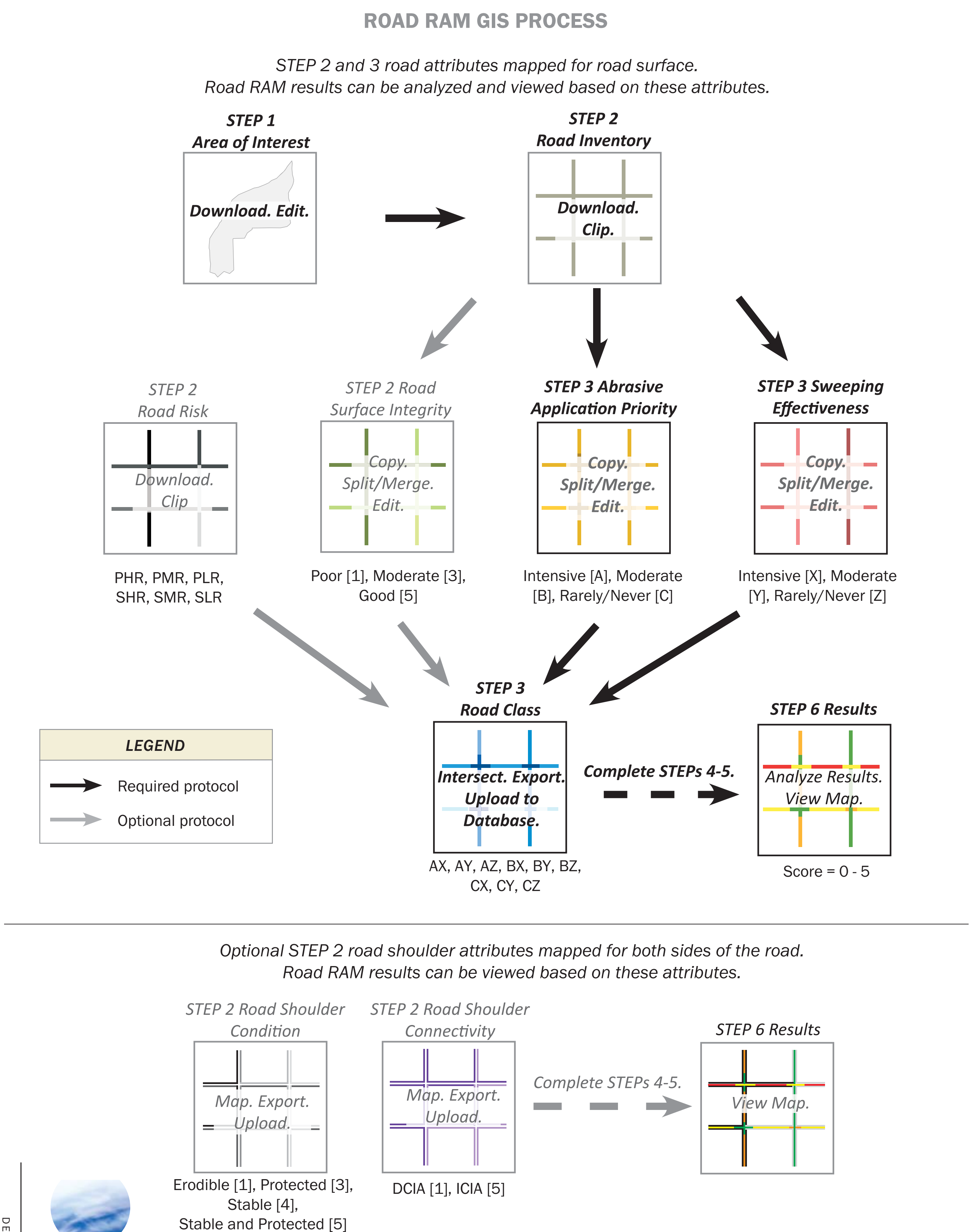
DOWNLOAD TEMPLATE FROM DATABASE

1. Download STEP 2 template zip file from the database.
   a. Go to “Downloads” -> “Shapefiles” -> “RoadRAM_STEP2Inventory.shp.zip”.
   b. Save to computer.
   c. Click “Parent Directory” to return to main page.

GIS PROCEDURES

1. In ArcGIS, *clip* STEP 2 Inventory shapefile using STEP 1 area of interest shapefile, where suggested naming convention is Inventory_AreaYear[3].
2. Download the Road RAM Inventory symbology layer from the website to display the roads in standardized Road RAM colors.

[3] Where “Area” and “Year” are consistent with STEP 1 designations.



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ROAD RAM GIS PROCESS

FIGURE 1.9

a. Go to “Downloads” -> “Symbology” -> “RoadRAMSym_Inventory.lyr”.
b. Save to computer.
c. Click “Parent Directory” to return to main page.
d. *Apply symbology layer.*

3. As appropriate, define additional road attributes for roads within the area of interest. See below for details.

ADDITIONAL STEP 2 GUIDANCE

OPTIONAL ROAD ATTRIBUTES

RULES
- **Do not delete any feature within the STEP 2 optional road attribute shapefiles.**
- **If no road attribute data is available for a road, the associated field in the attribute table should be left blank.**

Depending on the data analysis needs of the user (see *Technical Document Chapter 10: Application of Road RAM Data and Results*), the user may map additional road attributes as desired, some of which are completed in association with PLRM. Below are the protocols to map these optional road attributes and integrate them into the Road RAM database (see Figure 1.9). **Note: *Italicized words* indicate GIS commands detailed in *Part III: GIS Commands*.**

PLRM DEFAULT ROAD RISK LAYER

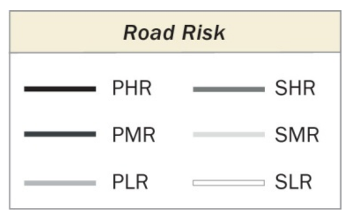
Download template from database

1. Download the STEP 2 Road Risk zip file from the database.
   a. Go to “Downloads” -> “Shapefiles” -> “RoadRAM_STEP2Risk.shp.zip”.
   b. Save to computer.
   c. Click “Parent Directory” to return to main page.

RULE
- **Road risk values are restricted to “PHR”, “PMR”, “PLR”, “SHR”, “SMR”, or “SLR”.**

GIS Procedures

1. In ArcGIS, *clip* STEP 2 Road Risk shapefile using STEP 1 area of interest shapefile to create new shapefile, suggested naming convention is Risk_AreaYear[3].
2. Download the Road RAM Road Risk symbology layer from the website to display the roads in standardized Road RAM colors (shown at right).
   a. Go to “Downloads” -> “Symbology” -> “RoadRAMSym_Risk.lyr.”
   b. Save to computer.
   c. Click “Parent Directory” to return to main page.
   d. *Apply symbology layer.*



ROAD SURFACE INTEGRITY

Map road surface integrity

1. Map the road surface integrity for all roads within the defined area of interest. This may be most easily done on a hard copy map in the field or using Google StreetView. Road surface integrity is rated as Poor, Moderate or Good. Figure 1.10 provides guidance for categorizing road surface integrity.

GIS Procedures

1. In ArcGIS, *copy baselayer* to create shapefile, where suggested naming convention is RSI_AreaYear[3].
2. Add field to attribute table.
   RSI: Field name is “RSI;” field type is short integer.
3. *Split* and/or *Merge features* as necessary to distinguish differences in road surface integrity.
   Polyline features are split and merged to differentiate between road surface integrity only. Breaks in features should correspond spatially to changes in the road surface integrity along a road. The mapping

Cracking			Distribution	
SEVERE cracking (high sediment storage capacity) Crack width >2"; Spalling[1] evident				HIGH distribution Covers >30% of road surface; Highly developed interconnected pattern
MEDIUM cracking Crack width 3/8 - 2"; Light spalling[1] evident'				MEDIUM distribution 5 - 30% of road surface; Some inter-connected cracking
LOW cracking (low sediment storage capacity) Hairline (<3/8") cracks; Minor weathering of road surface (shown)				LOW distribution Covers <5% of road surface; Parallel cracking; Little to no interconnected network

Road surface integrity considers both the severity of the pavement cracking (in terms of storage capacity of sediment), as well as the distribution of the cracking across the entire surface.

SEVERE cracking + HIGH or MEDIUM distribution = **POOR** integrity
SEVERE cracking + LOW distribution = **MODERATE** integrity
MEDIUM cracking + HIGH distribution = **POOR** integrity
MEDIUM cracking + MEDIUM to LOW distribution = **MODERATE** integrity
LOW CRACKING + HIGH distribution = **MODERATE** integrity
LOW CRACKING + MEDIUM or LOW distribution = **GOOD** integrity
NO cracking = **GOOD** integrity

Observations are based on the current state of pavement cracking; filled cracks have low to no storage capacity.
Definitions are based on the *Pavement Condition Index Distress Identification Manual* (MTC and ERES Consultants 2002).
[1]Spalling is the breakdown of material along the side of the crack.

ROAD SURFACE INTEGRITY EXAMPLES

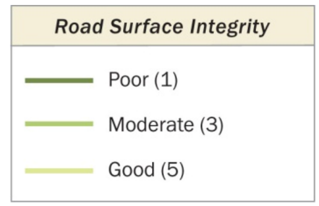
FIGURE 1.10

resolution is determined by the user; however, no smaller than one street block is the recommended level of effort.

4. *Edit attribute table* to assign appropriate road surface integrity designation to each line feature. For any features where the road surface integrity is unknown, leave field blank.
   <u>1</u>: Poor
   <u>3</u>: Moderate
   <u>5</u>: Good
   <u>Quick Tip</u>: Use *Field Calculator* to quickly add remaining values to field.

> **RULE**
> - **Road surface integrity values are restricted to "1", "3", "5", or blank.**

5. Download the Road RAM Road Surface Integrity symbology layer from the website to display the roads in standardized Road RAM colors (shown at right).
   a. Go to "Download" -> "Symbology" -> "RoadRAMSym_RSI.lyr".
   b. Save to computer.
   c. Click "Parent Directory" to return to main page.
   d. *Apply symbology layer.*



ROAD SHOULDER CONDITION

Road shoulder condition is mapped for both sides of the road.

Map road shoulder condition

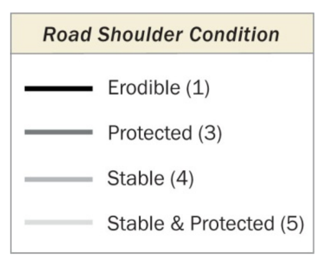
1. Follow PLRM Applications Guide (Northwest Hydraulics Consultants [NHC] et al. 2010), Chapter 5 to map the road shoulder condition for both road shoulders for the roads within the area of interest.

GIS Procedures

1. Create appropriate GIS shapefile following PLRM Applications Guide (Northwest Hydraulics Consultants [NHC] et al. 2010), Chapter 5.
2. Edit attribute table to convert text values to integers required for Road RAM database. For any features where the road shoulder condition is unknown, leave field blank.
   <u>1</u>: Erodible
   <u>3</u>: Protected
   <u>4</u>: Stable
   <u>5</u>: Stable and Protected
   <u>Quick Tip</u>: Use *Field Calculator* to convert string values to integers.

> **RULE**
> - **Road shoulder condition values are restricted to "1", "3", "4", "5", or blank.**

3. Download the Road RAM Road Shoulder Condition symbology layer from the website to display the roads in standardized Road RAM colors (shown at right).
   a. Go to "Downloads" -> "Symbology" -> "RoadRAMSym_RSCondition.lyr".
   b. Save to computer.
   c. Click "Parent Directory" to return to main page.
   d. *Apply symbology layer.*



ROAD SHOULDER CONNECTIVITY

Road shoulder connectivity is mapped for both sides of the road.

Map road shoulder connectivity

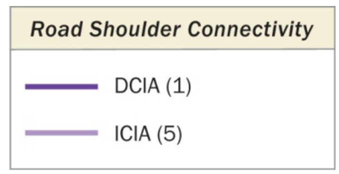
1. Follow PLRM Applications Guide (NHC et al. 2010), Chapter 5 to map the road shoulder connectivity for both road shoulders for the roads within the area of interest.

GIS Procedures

1. Create appropriate GIS shapefile following PLRM Applications Guide (Northwest Hydraulics Consultants [NHC] et al. 2010), Chapter 5.
2. Edit attribute table to convert text values to integers required for Road RAM database. For any features where the road shoulder connectivity is unknown, leave field blank.
   1: DCIA
   5: ICIA
   Quick Tip: Use *Field Calculator* to convert string values to integers.

> **RULE**
> - **Road shoulder connectivity values are restricted to "1", "5", or blank.**

3. Download the Road RAM Road Shoulder Connectivity symbology layer from the website to display the roads in standardized Road RAM colors (shown at right).
   a. Go to "Downloads" -> "Symbology" -> "RoadRAMSym_RSConnectivity.lyr".
   b. Save to computer.
   c. Click "Parent Directory" to return to main page.
   d. *Apply symbology layer.*



UPDATING STEP 2 DATA

The process for updating STEP 2 data is presented in Figure 1.8. In the event that STEP 2 data needs to be updated, it is likely for one of three reasons: (1) there was a mistake in the initial categorization (Figure 1.8B), (2) the road attributes have changed over time (Figure 1.8D), or (3) there are changes in the road inventory baselayer (Figure 1.8E). New roads may be constructed and/or existing roads may be relocated with new housing developments and other roads may be removed based on changes in adjacent land uses, leading to changes in the baselayer. If substantial changes have been made throughout the Lake Tahoe Basin, ideally an updated Road RAM inventory baselayer will be added to the Downloads page and available to all users. Contact the Database Administrator for more information.

ROAD RAM STEP 3 – CLASSIFY ROADS

STEP 3 OVERVIEW

The user groups roads within the area of interest by similar road maintenance practices (abrasive application and sweeping). The STEP 3 outputs are a spatial display of the roads within the area of interest, the populated database, and a road class summary query (Table 1.3). Figure 1.9 illustrates the data collection and analysis flow of spatial information for STEPs 2 and 3. STEP 3 includes creating the required abrasive application priority and sweeping effectiveness shapefiles; intersecting STEP 2 and STEP 3 road attribute shapefiles to create the road class shapefile; clipping the road class shapefile to the appropriate STEP 1 areas of interest; and uploading the GIS information to the database.

Table 1.3. GIS analysis and database interaction for Road RAM STEP 3.

Road RAM STEP #	Road RAM STEP Name	GIS Analysis	Online Database	Frequency of STEP completion
3	CLASSIFY Roads	Copy Split/Merge Intersect Clip Export	Upload Data View Map View Query	2-5 years

The main purpose of STEP 3 is to group all roads within the area of interest into one of up to 9 classes based on similar road maintenance practices (Table 1.4). The classification allows for the spatial extrapolation of Road RAM scores obtained for a series of discrete segments. If the user intends only to track the road segment condition over time (i.e., will not spatially extrapolate road segment results to road class), STEP 3 is not necessary (see Figure 0.1).

Table 1.4. Road Class matrix indicating the intersection of relative sources and sinks to create 9 potential road class categories.

Sweeping Effectiveness (*sinks*)	**Abrasive Application Priority (*sources*)**		
	Intensive (A) *high sources*	Moderate (B)	Rarely to Never (C) *low sources*
Intensive (X) *high sinks*	AX	BX	CX
Moderate (Y)	AY	BY	CY
Rarely to Never (Z) *low sinks*	AZ	BZ	CZ

PROTOCOLS

Time Required: 5-15 hours, depending on the miles of road in area of interest

Equipment and Expertise Required:

- 2 hard copies of street map within area of interest and labeled street names
- 4 markers (preferably red, yellow, blue and green)
- STEP 2 Road Inventory baselayer shapefile
- Computer with ArcGIS 9 and internet connection
- Knowledge of road maintenance practices within area of interest
- Familiarity with ArcGIS 9

RULES

- **Road classification is <u>required</u> if user desires to spatially extrapolate road segment scores to a greater road network.**
- **Road classification reflects relative FSP sources and sinks as a result of actual road maintenance practices.**
- **Definitions of road class are jurisdiction specific and will vary across jurisdictions.**

Note: ***Italicized*** **words indicate GIS commands detailed in the** ***Part III: GIS Commands*****.**

CATEGORIZE ROAD MAINTENANCE PRACTICES

The purpose of road class within Road RAM is to facilitate the spatial extrapolation of discrete road field observations to a greater area of roads (see lower portion of Figure 0.1). The below protocols represent a simple stepwise process for jurisdictions to classify the roads within the defined area of interest. Road classification is focused on the relative amount, frequency and type of abrasives (pollutant sources) applied to the roads within the area of interest and the relative sweeping effectiveness, snow haul efforts, etc (pollutant sinks) to remove pollutants from the road surface as a result of road maintenance practices. The user may choose to apply the example below or expand the road class definitions as they desire, as long as each road class category specifically represents a series of roads that are consistently maintained based on the expected sources and sinks as a result of road maintenance practices.

The only strict guideline in defining the actual practices for each road class beyond abrasive and sweeping efforts is to ensure that the relative expected annual source and sink categories are preserved, such that source class A has a higher expected annual source input and/or generation of FSP than B, than C. Similarly, the sink class X has a higher annual removal capability of road pollutants than Y, than Z. The Road RAM tool only requires the road class map for Road RAM spatial extrapolation, but the detailed road maintenance practices that define each road class should be clear and documented to ensure consistent application of the practices defined in the Road RAM tool.

1. Using a street map, delineate relative abrasive application priority for all roads in area of interest. Abrasive application priority includes the frequency, intensity, type and amount of abrasives applied each winter. Through the classification process, users should document in detail the abrasive application practices applied to each category to ensure clear communication of categories. Users are encouraged to look at their jurisdiction-wide practices and determine the appropriate breaks to categorize "intensive" and "rarely to never" locations.
   INTENSIVE (A): Delineate all road areas where the relatively greatest amount of FSP sources applied and/or generated on a road occur as a result of road maintenance practices each year in *RED*. "Intensive" designates the roads where abrasives are applied most frequently and/or in the largest quantity and/or with the greatest initial FSP load and/or using the least durable abrasive type. The users are encouraged to critically evaluate the characteristics of the road maintenance practices that would result in the relatively largest source of FSP based on abrasive application practices alone. These locations are likely sanded first during every significant winter event when traffic safety is a concern. These may include major intersections, bus routes, schools, steep slopes, dangerous curves, etc. Abrasive application likely targets spot locations, rather than along lengths of roads. Mapping should reflect this.
   RARELY TO NEVER (C): Delineate all roads within the area of interest where the least intensive road abrasive application occurs in *YELLOW*. These are locations where abrasives are applied the least frequently and/or in the smallest amount and/or with the smallest initial FSP load and/or using the most durable road abrasive type. "Rarely to Never" roads are only sanded during the iciest winter events.
   MODERATE (B): All remaining roads fall into the moderate abrasive application group and are left unmarked on the street map.
   Using a separate street map, delineate relative road sweeping effectiveness for all roads in area of interest. Sweeping effectiveness includes both the frequency of recovery operations and the **sweeper type**. Sweeping effectiveness encompasses any road abrasive removal practices, including snow haul, as well as the type of sweeper used. The most effective sweeper is defined as the sweeper that most successfully targets the removal of FSP (Table 1.5). The consideration of pollutant sinks should focus only

on the impervious road surface prior to a runoff event. Sediment traps, other roadside Treatment BMPs, or pervious dispersion areas should not be considered during road classification, because these treatment features require a runoff event to transport pollutants downslope from the road surface. The pollutant sink categories must focus upon direct source control efforts that remove pollutants from the impervious surface prior to subsequent transport by runoff. Users are encouraged to look at their jurisdiction-wide practices and determine the appropriate breaks to categorize the relative "intensive" and "rarely to never" pollutant recovery locations.

Table 1.5. Sweeper Types, presented in decreasing order of effectiveness of road surface FSP removal.

Efficiency	Sweeper Type	Example
High	**High-efficiency vacuum-assisted (dustless)**	Schwarze EV1
↓	**Regenerative air (dustless)**	Elgin Crosswind, Schwarze A-Series
	Tandem operation (mechanical + vacuum sweeper)	Elgin Eagle or Mobil Mechanical (1988) followed by TYMCO vacuum sweeper
Low	**Mechanical broom (1988 model or newer)**	Elgin Eagle, Mobil Mechanical (1988)

INTENSIVE (X): Highlight all roads that are priority sweeping locations in *BLUE*. "Intensive" designates the roads where sweeping is conducted most frequently with the jurisdiction's most effective sweeper (see Table 1.5). The relative pollutant removal from snow haul or other practices that would remove abrasives or other particulate pollutants from the road surface should also be considered and incorporated into pollutant sink mapping as appropriate. These locations are the first to be swept once conditions allow effective pollutant recovery. These may include high abrasive application sites, as well as the roads connecting priority application sites. Road sweeping likely occurs along lengths of road, rather than in targeted spot locations. Mapping should reflect this.
RARELY TO NEVER (Z): Delineate all road areas where sweeping occurs least often within a jurisdiction in *GREEN*. These "Rarely to Never" locations are where sweeping is conducted least frequently with the jurisdiction's least effective sweeper (see Table 1.5).
MODERATE (Y): All remaining roads fall into the moderate road sweeping frequency group and are left unmarked on the street map.

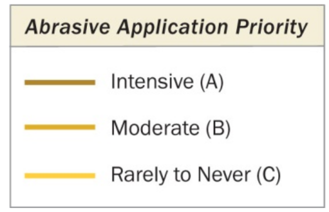
GIS PROCEDURES: ABRASIVE APPLICATION PRIORITY

1. In ArcGIS, *copy baselayer* to create shapefile, where suggested naming convention is AA_AreaYear[4].
2. *Add field to attribute table*.
   RoadAA: Field name is "RoadAA;" field type is text.
3. *Split and/or Merge features* as necessary to distinguish differences in abrasive application priority based on hard copy map.
4. *Edit attribute table* to assign appropriate abrasive application priority designation to each feature.
   A: Intensive locations (red lines)
   C: Rarely to Never locations (yellow lines)
   B: Moderate locations (all remaining lines)
   Quick Tip: Use *Field Calculator* to quickly add remaining field data.

RULES
- **Do not delete any features from the inventory baselayer.**
- **Abrasive application priority values are restricted to "A", "B", or "C". Blanks are not allowed.**

[4] Where "Area" and "Year" are consistent with STEP 1 designations.

5. Download the Road RAM Abrasive Application symbology layer from the website to display the roads in standardized Road RAM colors (shown at right).
   a. Go to “Downloads” -> “Symbology” -> “RoadRAMSym_AA.lyr”.
   b. Save to computer.
   c. Click “Parent Directory” to return to main page.
   d. *Apply symbology layer.*

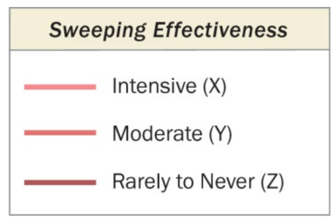


GIS PROCEDURES: SWEEPING EFFECTIVENESS

1. *Copy baselayer* to create shapefile, where suggested naming convention is SE_AreaYear[4].
2. *Add field to attribute table.*
   RoadSE: Field name is “RoadSE;” field type is text.
3. *Split and/or Merge features* as necessary to distinguish differences in sweeping effectiveness based on hard copy map.

RULES
- **Do not delete any features from the inventory baselayer.**
- **Sweeping effectiveness values are restricted to “X”, “Y”, or “Z”. Blanks are not allowed.**

4. *Edit attribute table* to assign appropriate sweeping effectiveness designation to each feature.
   X: Intensive locations (blue lines)
   Z: Rarely to Never locations (green lines)
   Y: Moderate locations (all remaining lines)
   Quick Tip: Use *Field Calculator* to quickly add remaining field data.
5. Download the Road RAM Sweeping Effectiveness symbology layer from the website to display the roads in standardized Road RAM colors (shown at right).
   a. Go to “Downloads” -> “Symbology” -> “RoadRAMSym_SE.lyr”.
   b. Save to computer.
   c. Click “Parent Directory” to return to main page.
   d. *Apply symbology layer.*



GIS PROCEDURES: ROAD CLASS

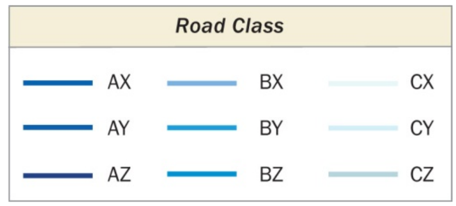
1. *Intersect* AA_AreaYear , SE_AreaYear and optional STEP 2 road attribute shapefiles (e.g., Risk_AreaYear, RSI_AreaYear) to create a new shapefile where suggested naming convention is STEP3_AreaYear[4]. See *Part III: GIS Commands* for tips on intersecting multiple shapefiles and updating the attribute table. Note: At this time optional road shoulder attributes mapped for both sides of the road (e.g, RSC, RSConnectivity) cannot be included in the STEP 3 shapefile.
2. *Add field to attribute table*.
   RoadClass: Field name is “RoadClass;” field type is text.
   Note: The attribute table of the new shapefile should contain all fields associated with shapefiles that were intersected (e.g., “RoadAA”, “RoadSE”, “RoadRisk”, etc.).
3. *Concatenate fields*.
   a. Concatenate “RoadAA” and “RoadSE” in “RoadClass” field. Depending on the mapping, up to 9 road classes will be created based on Table 1.6.
   b. Formula is [RoadAA]+[RoadSE].

RULE
- **Road class values are restricted to “AX”, “AY”, “AZ”, “BX”, “BY”, “BZ”, “CX”, “CY”, or “CZ”. Blanks are not allowed.**

Table 1.6. Road Class Matrix

Sweeping Effectiveness (*sinks*)	Abrasive Application Priority (*sources*)		
	Intensive (A) *high sources*	Moderate (B)	Rarely to Never (C) *low sources*
Intensive (X) *high sinks*	AX	BX	CX
Moderate (Y)	AY	BY	CY
Rarely to Never (Z) *low sinks*	AZ	BZ	CZ

4. Download the Road RAM Road Class symbology layer from the website to display the roads in standardized Road RAM colors (shown below).
   a. Go to “Downloads” -> “Symbology” -> “RoadRAMSym_Class.lyr”.
   b. Save to computer.
   c. Click “Parent Directory” to return to main page.
   d. *Apply symbology layer.*



5. Calculate road length.
   a. *Add field to attribute table*; field name is “RoadLength” and field type is double. Precision and scale values are the user’s discretion.
   b. Use *Calculate Geomet*ry to calculate the length in feet.
6. Create unique ID for each STEP 3 road polyline.
   a. *Add field to attribute table*; field name is “ID” and field type is text.
   b. Use *Field Calculator* for “ID.” Values equal [FID].
   c. *Add field to attribute table*; field name is “Name” and field type is text.
   d. Use *Field Calculator* for “Name.” Values equal [ID] + “_” + [StreetName]
   e. Delete “ID” and “Streetname” fields from attribute table.

RULE
- **Ensure that “Name” field is the Primary Display Field for the shapefile (see *Part III: GIS Commands*).**

7. *Clip* the road class shapefile to the appropriate STEP 1 area(s) of interest as necessary, where suggested naming convention is STEP3_AreaYear[4]. (See Figure 1.7 for guidance.)
8. *Export attribute table as *.txt file*, where suggested naming convention is STEP3_ AreaYear[4].
9. *Export shapefile to *.kmz*, where suggested naming convention is STEP3_ AreaYear[4].

RULE
- **The attribute table (*.csv) must be uploaded first, then the corresponding shapefile (*.kmz).**

UPLOAD DATA TO DATABASE

1. Import attribute table from Excel into database.
   a. Convert exported *.txt file to *.csv file using Microsoft Excel. Figure 1.11 shows the proper formatting for the *.csv file, including required headers and fields.

	A	B	C	D	E	F	G	H	I	J	K
1	**FID_**	**RoadAA**	**RoadSE**	**RoadConn**	**RoadRSI**	**RoadRSCNE**	**RoadRSCSW**	**RoadRisk**	**RoadClass**	**Name**	**RoadLength**
2		A	Y					PLR	AY	0_LAKESHORE BLVD	376.5

Figure 1.11. Proper formatting for STEP 3 *.csv file. Column headers (bolded in row 1) must be formatted as shown. “RoadAA”, “RoadSE”, “RoadClass”, “Name”, and “RoadLength” must have values in the fields (Row 2).

b. Upload *.csv file to database. Go to “Uploads” -> “CSV Uploads.”
c. Select “Step 3- Table” table to receive the data (Figure 1.12).
d. Browse for appropriate *.csv file.
e. Click “Process.” See *Part IV: Troubleshooting – Database Uploads* for guidance as necessary.

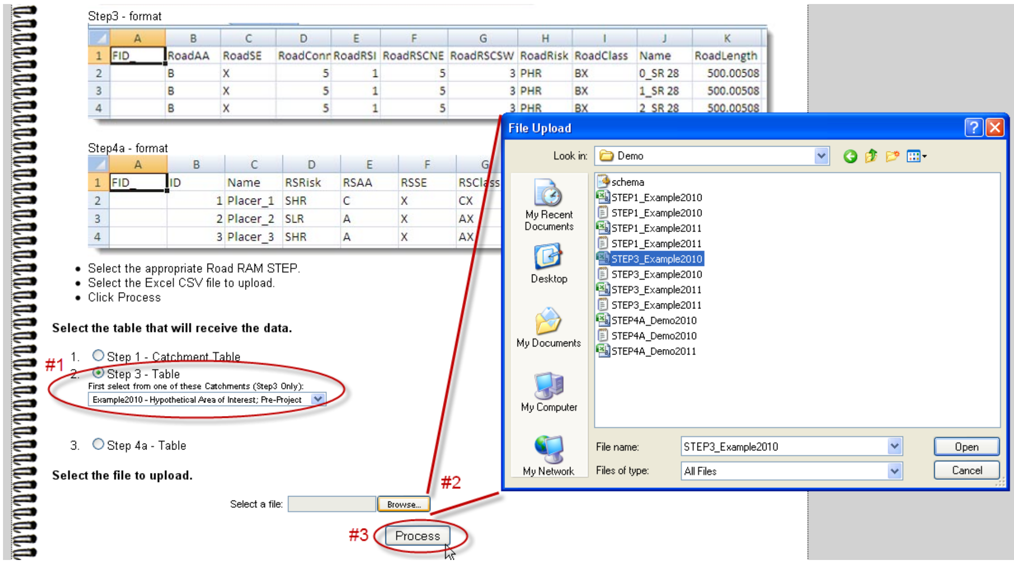


Figure 1.12. STEP 3 *.csv Upload.

2. Import *.kmz shapefile into database.
   a. Go to “Uploads” -> “KMZ Uploads.”
   b. Select “(kmz) Catchment File” table to receive the data (Figure 1.13).
   c. Select the appropriate area of interest from the drop down menu.
   d. Browse for appropriate *.kmz file.
   e. Click “Process.” See *Part IV: Troubleshooting – Database Uploads* for guidance on common importing errors.
   f. Complete the process of uploading the STEP 3 roads. Before closing the window wait for the following message to appear “Your file upload was successful.” Click the hyperlink “Click this line to start the process.” to complete the uploading process.

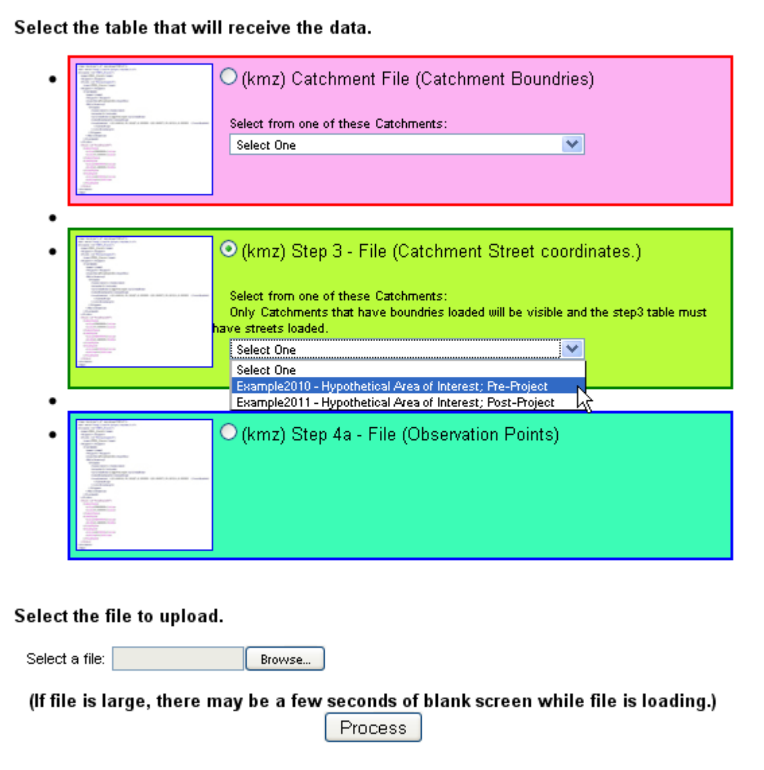


Figure 1.13. STEP 3 *.kmz Upload.

3. View STEP 3 Map to verify upload.
   a. Go “Maps” -> “STEP 3 Road Attributes.”
   b. Locate appropriate area of interest (Figure 1.14) and select the road attribute to display on the map (AA =Abrasive Application Priority, CLASS = Road Class, RISK = PLRM Road Risk, RSI = Road Surface Integrity, and SE = Sweeping Effectiveness).
   c. Fig1.14bFig1.14aFig1.14bClick map icon on right to view map and verify roads. Symbology used by database is consistent with the GIS symbology layers and the legends provided in this document.

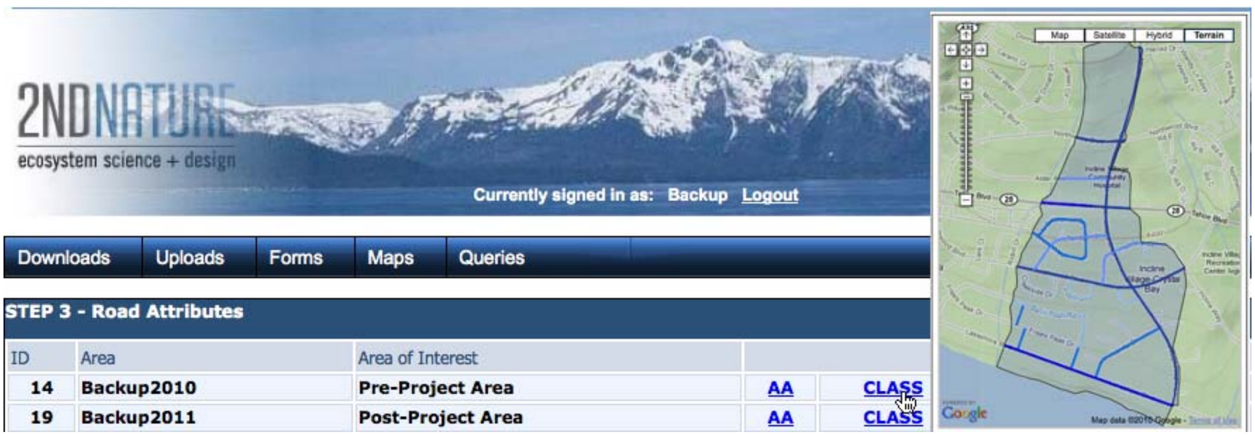


Figure 1.14. View STEP 3 Map. Selecting a road attribute, in this example, CLASS, will produce a Google Map pop up of the area of interest (shown on right).

4. View STEP 3 Road Attribute Summary Query. This query provides a summary of the miles and percent distribution of each road attribute category for the area of interest.
   a. Go to “Queries” -> “Step 3 Road Attribute Summary”.
   b. Select the appropriate area of interest from the dropdown menu (Figure 1.15) to view a summary of road attribute statistics. Clicking on the chart graphic creates a pie chart of the distribution of categories for each road attribute.

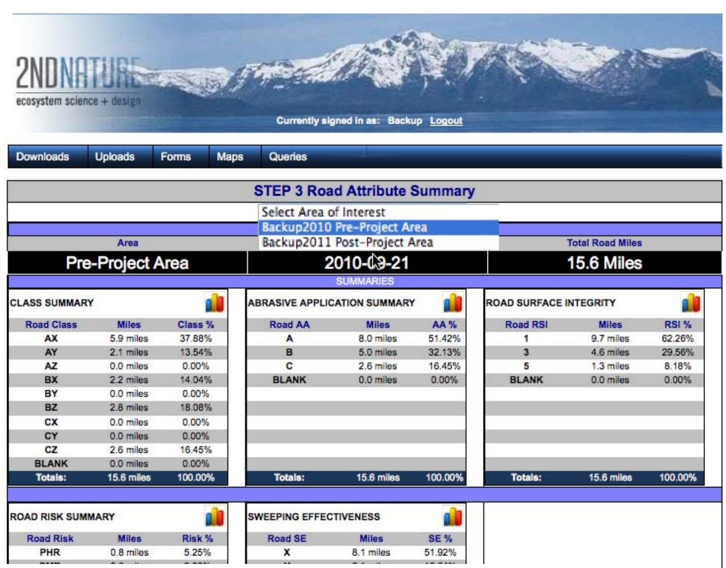


Figure 1.15. View STEP 3 Query.

ADDITIONAL STEP 3 GUIDANCE

UPDATING STEP 3 DATA

The process for updating STEP 3 data is presented in Figure 1.8. In the event that STEP 3 data needs to be updated, it is likely for one of three reasons: (1) there was a mistake in the initial categorization (Figure 1.8B) or (2) the road maintenance practices within a jurisdiction have changed significantly (Figure 1.8D). As jurisdictions document these road maintenance practices and as existing scientific information improves, it is anticipated that the spatial distribution of road maintenance practices will need to be updated. Increased monitoring, as well as Road RAM results, will inform jurisdictions on how to spatially improve their road maintenance efforts to improve water quality. As such, the designation of Abrasive Application Priority and Sweeping Effectiveness is expected to change over time.

RULE

- **If a *.csv or *.kmz file is uploaded with the same STEP 1 "Area" and STEP 3 "Name" values as an existing database entry, the existing file is overwritten and the information is deleted.**

ROAD RAM STEP 4 – SELECT ROAD SEGMENTS AND CONDUCT FIELD EVALUATIONS

STEP 4 OVERVIEW

The user selects the locations (road segments) for discrete field observations and assigns each road segment observation point a unique ID; and completes the field observations and inputs the data into the database to determine a Road RAM Score for the date of observation. The two sub-STEPs are:

RULE
- **STEPs 4A and 4B are required for all users.**

STEP 4A. Select specific road segments for evaluation (conducted yearly or less often) and import to database.

STEP 4B. Conduct field observations at selected road segments and populate database.

The STEP 4 outputs are a spatial display of the roads segments and the populated Road RAM Database (Table 1.7).

Table 1.7. GIS analysis and database interaction for Road RAM STEP 4.

Road RAM STEP #	Road RAM STEP Name	GIS Analysis	Online Database	Frequency of STEP completion
4A	Select ROAD SEGMENTS	Edit Spatial Join Export	Download Data Upload Data View Map View Query	2-5 years
4B	Conduct FIELD EVALUATIONS	n/a	Enter Data	Seasonally

STEP 4A PROTOCOLS

Time Required: 5-10 hours, depending on miles of road and level of analysis

Equipment and Expertise Required:
- Computer equipped with ArcGIS 9 and internet access
- STEP 3 Road Class shapefile and map
- Familiarity with ArcGIS 9

Crediting Program
- **The Crediting Program recommends a minimum number of road segments per road class (*see Part II: Alignment with Crediting Program, page 2.2*).**

Note: Italicized words indicate GIS commands detailed in the *Part III: GIS Commands*.

SELECT ROAD SEGMENT LOCATIONS

1. Based on user analysis objectives, develop criteria for selecting road segments for observations. The STEP 4A Additional Step Guidance section (page 1.28) provides suggestions for developing selection criteria.
2. Using the developed criteria, select specific locations within the area of interest as road segment observation points. Mark these locations on a hard copy of the STEP 3 map.

DOWNLOAD TEMPLATE FROM DATABASE

1. Download STEP 4A template zip file from the database.
   a. Go to “Downloads” -> “Shapefiles” ->“RoadRAM_STEP4Atemplate.shp.zip”.
   b. Rename file and save to computer. Suggested naming convention for shapefile is STEP4A_UserYear[5].
   c. Click “Parent Directory” to return to main page.

[5] Where “User” is the Road RAM database user name and “Year” is either the year the road segment was selected or the year the STEPs 2 and 3 road attributes were defined. See Figures 10 and 11 for clarification.

GIS PROCEDURES

> **RULES**
> - **For Road RAM purposes, the accuracy of the road segment location is not important can be ± 250 ft in either direction.**
> - **The "Name" field is required to have the prefix "User_" to ensure proper upload to the database.**
> - **Ensure that "Name" field is the Primary Display Field for the shapefile (see *Part III: GIS Commands*).**

1. In ArcGIS, *edit feature* to add points of specific locations as shown on hardcopy map.
   To improve accuracy of spatial analysis, points should be mapped on STEP 3 road segments.
   GIS tip: Use snap tool when creating points.
2. *Edit attribute table* to enter a unique ID for each selected road segment in "Name" column.
   - Required naming convention is "User_#_Year" where User is the name of the user who will upload the data to the database, # is sequential integer, and year is either the year the road segment was created or the STEPs 2 and 3 road attributes were categorized (see Figures 1.8 and 1.9).
   - Shortcut tip: Add a temporary field to the attribute table, "ID" as a string. Calculate "ID" = "FID" and use *Field Calculator* to calculate "Name", where formula is "User_" + [ID#] + "_Year".
3. *Spatial Join* all attributes from STEP 3 shapefile to STEP 4A shapefile, where suggested naming convention is "STEP4A_User[5]".
   Note: The attribute table of the new shapefile should contain all fields associated with existing shapefiles (e.g., "RoadAA, "RoadSE," "RoadRisk," etc.).
4. *Export attribute table as *.txt file*, where suggested naming convention is STEP4A_User[5].
5. *Export shapefile to *.kmz*, where suggested naming convention is STEP4A_User[5].

> **RULE**
> - **The attribute table (*.csv) must be uploaded first, then the corresponding shapefile (*.kmz).**

UPLOAD DATA TO DATABASE

1. Import attribute table from Excel into database.
   a. Convert exported *.txt file to *.csv file using Microsoft Excel. Figure 1.16 shows the proper formatting for the *.csv file, including required headers and fields. Note: Fields must be renamed from shapefile attribute table.

	A	B	C	D	E	F	G	H	I	J	K
1	**FID_**	**ID**	**Name**	**RSRisk**	**RSAA**	**RSSE**	**RSClass**	**RSConn**	**RSCNE**	**RSCSW**	**RSI**
2			Demo_0_2010		A	X	AX				

Figure 1.16. Proper formatting for STEP 4A *.csv file. Column headers (bolded in row 1) must be formatted as shown. "Name", "RSAA", "RSSE", and "RSClass" must have values in the fields (Row 2).

   b. Upload *.csv file to database.
      i. Go to "Uploads" -> "CSV Uploads."
   c. Select "Step 4a- Table" to receive the data (Figure 1.17).
   d. Browse for appropriate *.csv file.
   e. Click "Process." See *Part IV: Troubleshooting* for guidance on common importing errors.

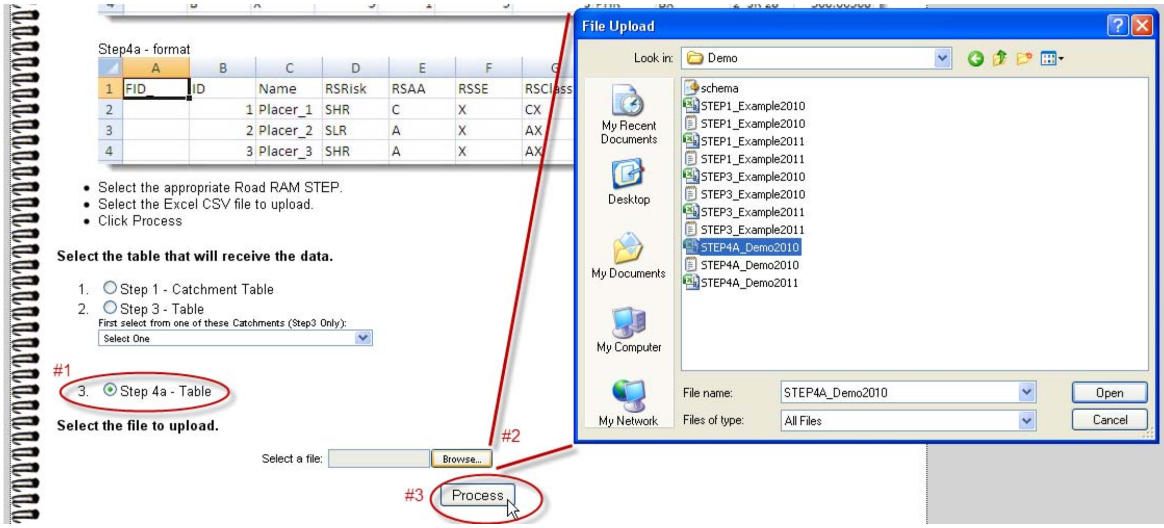


Figure 1.17. STEP 4A *.csv Upload.

2. Import *.kmz shapefile into database.
   a. Go to “Uploads” -> “KMZ Uploads.”
   b. Select “(kmz) Step 4a – File (Observation Points)” (Figure 1.18).
   c. Browse for appropriate *.kmz file.
   d. Click “Process.” See *Part IV: Troubleshooting* for guidance on common importing errors.

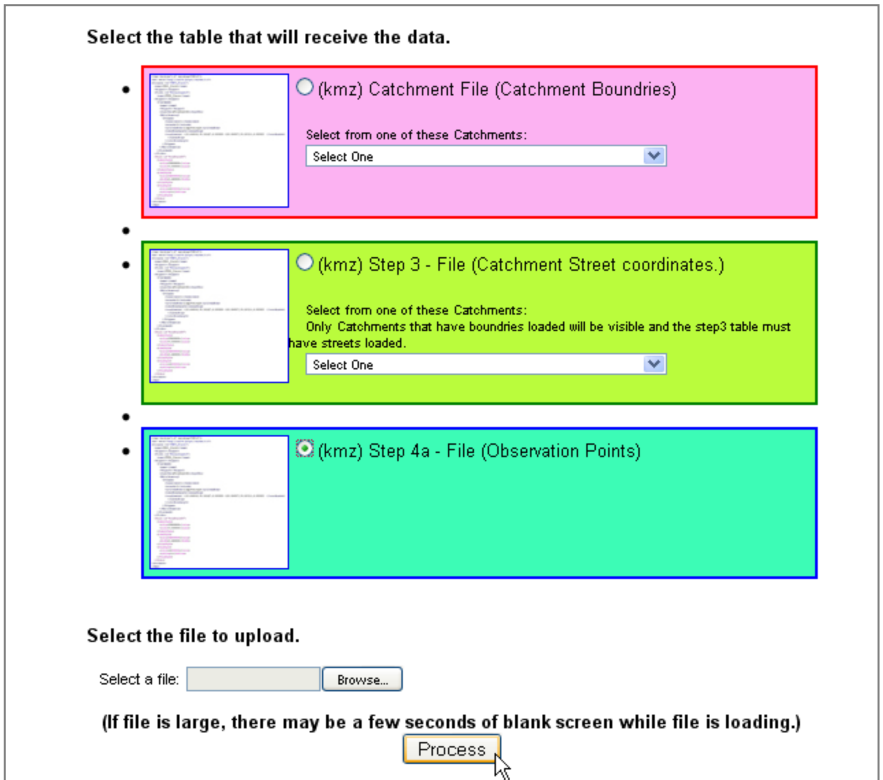


Figure 1.18. STEP 4A *.kmz Upload.

3. View STEP 4A Map to verify upload.
   a. Go “Maps” -> “STEP 4A Road Segments.” (Figure 1.19)

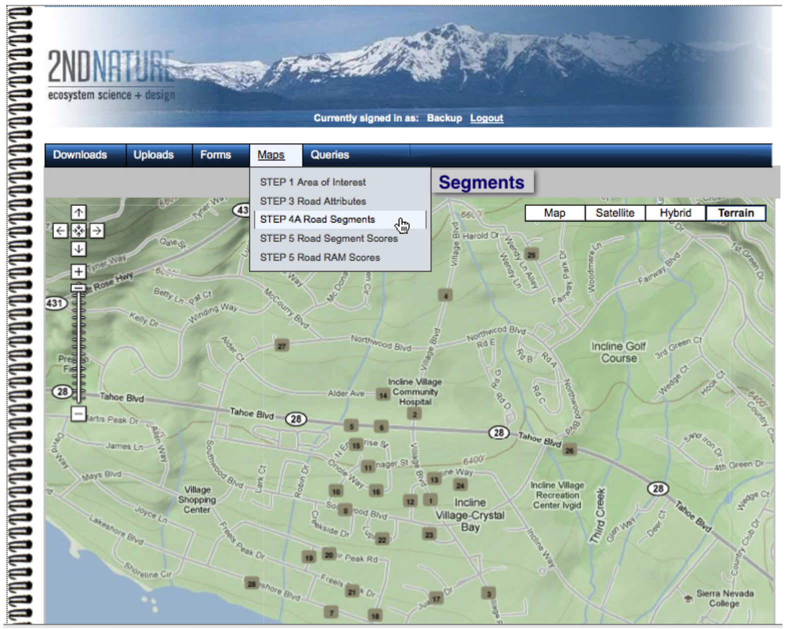


Figure 1.19. View STEP 4A Map.

4. View STEP 4A Road Class Summary Query. This query provides a summary of the number of road segments selected per area of interest and includes counts by road attribute categories, as appropriate.
   a. Go to “Queries” -> “Step 4A Road Segment Summary” (Figure 1.20). Clicking on the chart graphic creates a pie chart of the distribution of categories for each road attribute.

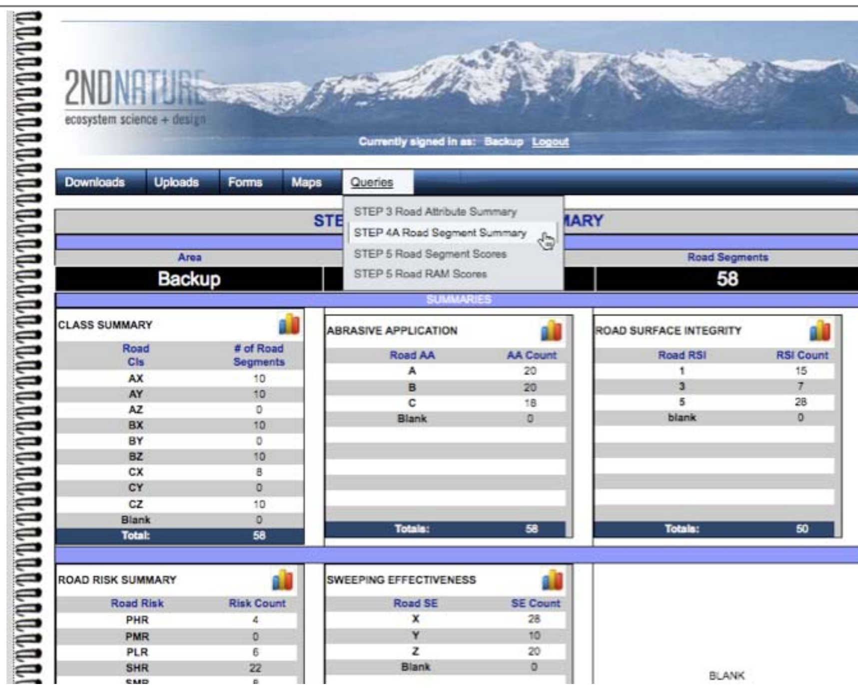


Figure 1.20. View STEP 4A Query.

ADDITIONAL STEP 4A GUIDANCE

ROAD SEGMENT SELECTION CRITERIA

Depending on the user's analysis objectives, road segments can be selected based on a range of attributes. Below are things to consider when selecting road segments.

NUMBER OF ROAD SEGMENTS

- If the Crediting Program is not a consideration, a minimum of 3 road segments should be selected per road attribute category, to allow calculation of the average and standard deviation of scores.
- If the user is implementing Road RAM to align with the Crediting Program, the user must select road segments within each road class based on the minimum requirements (see *Part II: Alignment with Crediting Program*).
- Consider the spatial scale of the area of interest (e.g., jurisdiction-wide, UPC, etc.). Users may choose to define a greater number of road segments than the minimum recommendation (see *Part II: Alignment with Crediting Program*). Selecting a greater number than recommended would (1) allow users to minimize selection bias by randomly selecting the observation sites for each Road RAM observation period, (2) ensure an adequate number of road segments are available per road class, in case the target SD is not achieved during an observation period, and (3) allow flexibility for a future observation period should some segments be inaccessible due to construction or other unforeseen circumstances.

SPATIAL DISTRIBUTION

Future Water Quality Improvement Projects: Locations where jurisdictions have plans for future water quality improvement projects (WQIP) may be targeted to inform the design characteristics of the project and to inform PLRM inputs. Improved understanding of the roads that are significant risks to water quality will assist jurisdictions in constructing water quality improvement projects that most efficiently target pollutant loading within the project area. The spatial analysis power of Road RAM can inform relative road conditions within the water quality improvement project area on a variety of timescales. Road RAM observations and results could also be used to compare road condition within multiple potential WQIP areas to assist with the prioritization of future projects.

ROAD ATTRIBUTES

Consider range of road characteristics, including road risk, road shoulder condition, road surface integrity, road shoulder connectivity, traffic density, slope etc.

Road Surface Integrity: Preliminary findings from controlled experiments indicate that poor road surface integrity is suspected to increase the risk to downslope water quality due to trapping of FSP within the cracks that cannot be recovered effectively by sweeping (2NDNATURE 2010a). Road segments exhibiting a range of road surface integrity may be selected to evaluate the observed changes in road condition from a road repaving project or examine the temporal changes in road condition as influenced by pavement quality. Rapid road surface degradation during certain stages of road surface condition is also hypothesized as a potential source of pollutants. This hypothesis has not yet been tested, but is being considered as a potential area of future research.

Road Shoulder Condition: Road shoulder condition is defined in the PLRM and is considered a potential influence on the annual condition of a road segment. The following are the water quality benefit assumptions of improving road shoulder condition: (1) an unprotected road shoulder is subjected to traffic and human disturbance and con provide a chronic source of native material onto the impervious road surface; (2) a stable road shoulder may reduce snow plow disturbance and associated erosion of the native soils; and (3) on roads where abrasives are frequently applied, a stable road shoulder may improve the efficiency of street sweepers to recover a greater fraction of the abrasives applied. Users may wish to select road segments to further test and validate these assumptions.

Road Shoulder Connectivity: In addition to the road condition, the connectivity of the road surface to local surface waters is a key determinant in the likelihood that pollutants reach Lake Tahoe. Users may choose to focus their Road RAM observations on those locations that have a higher potential to be transported to surface water and eventually Tahoe Basin. These include roads that are directly connected to the stormwater conveyance infrastructure, are in close proximity to surface water resources, and/or do not have associated treatment BMPs downslope to remove and/or retain pollutants. This analysis could be done during periods when conditions are assumed to be the worst to inform prioritization of abrasive application control strategies and/or pollutant recovery actions, as well as inform the future placement of WQIPs and Treatment BMPs.

PLRM Road Risk: Road risk, as developed and defined in PLRM (nhc et al. 2009a), is a proxy for abrasive application priority and is based solely on physiographic characteristics, including slope, traffic density, and adjacent land use. Users may wish to analyze temporal road condition differences across a range of road risk categories to (1) further refine the PLRM Road Methodology or (2) compare and/or refine jurisdiction road abrasive application practices based on these physiographic features.

UPDATING STEP 4A DATA

The process for updating STEP 4A data is presented in Figure 1.8. In the event that STEP 4A data needs to be updated, it is likely for one of three reasons: (1) there was a mistake in the initial placement of a road segment (Figure 1.8A), (2) the user wishes to add more observation points (Figure 1.8A), or (3) the STEP 3 data has been updated (Figure 1.8B,D-E).

RULES

- **If a *.csv or *.kmz file is uploaded with the same STEP 4A “Name” values as an existing database entry, the existing file is overwritten and the information is deleted.**

STEP 4B PROTOCOLS

Crediting Program
- **The Crediting Program recommends a minimum number of seasonal observation periods (see *Part II: Alignment with Crediting Program, page 2.2*).**

Personnel Required:

1-2 Field Personnel 10-15 minutes per road segment.

Equipment Required:

- 1'x'1 Square with Plastic Sheet
- Hand Broom
- Hard Edge
- Spray Bottle
- *Part V: Field Protocols and Datasheet*
- Camera
- Figures 1.21-1.24
- Calculator
- Duct Tape/Gorilla Tape
- Dustpan
- Wire Brush
- Funnel
- Paper Towels/Rags
- Pen
- 3 Graduated Cylinders (10ml, 100ml, 1000ml capacity)

Field personnel safety is of utmost importance. Use extreme caution when evaluating roads.

- Field personnel should first and foremost follow all jurisdiction-required safety protocols.
- Field vehicle should be parked completely on road shoulder, out of drive lane, and in area of high visibility.
- All field personnel should wear brightly colored safety vests.
- Establish a 'safety zone' with traffic cones.
  a. Place cones every 50-100 yards and extend a few feet into drive lane to create buffer for field personnel, while minimizing motorist disturbance and without forcing cars into oncoming traffic lane.
  b. Field personnel should set up all equipment within safety zone.
  c. Field personnel never stand outside of safety zone or between equipment and edge of safety zone.
  d. Unless absolutely necessary, do not stand/kneel with back to oncoming traffic.

TIMING OF FIELD OBSERVATIONS

Field observations on selected road segments may be conducted over multiple days, as long as no storm event requiring abrasive application or creating stormwater runoff occurs over the multi-day time span. Observations are grouped under a single observation period. The observation period is denoted by the first date and is formatted as YYYYMMDD (e.g., observation period "20101116" indicates the observations began November 16, 2010).

RULES
- **For best results, observations should be made when road surface is dry.**
- **When characterizing a road segment, walk the perimeter of the complete road segment and look at both road shoulders prior to completing measurements. Answers should be representative of the road segment as a whole.**
- **Enter all required information into field datasheet.**

ROAD SEGMENT METADATA (DATASHEET ROWS #1-2)

1. Arrive at specific road segment. Record RSID, date, time and personnel on datasheet (Row #1).
2. Define road segment area (10,000 ft^2 area) (Row #2). This step only needs to be completed during the first visit to a road segment.
   a. The width of the road segment is defined as the width between the two edges of continuous impervious area (Figure 1.21). Estimate average width of road segment by

Figure 1.21. Road Segment Width

walking the width from one edge of pavement to the other. Average human pace is 3 ft. Measure your pace prior to initiating STEP 4B and use your standard pace to estimate width. Additional impervious areas (bike lane, sidewalk, etc) that are beyond the right of way and are part of the continuous impervious surface from the center line must be included in the calculation of road segment width (Figure 1.22). For instance, if a lawn or pervious surface is located between the right of way and a sidewalk, the sidewalk is not included. Include all continuous impervious surfaces in road width, but do not add more than 20ft to the road segment width estimate for additional impervious area (see top of Figure 1.22B). Record the width of the road on field datasheet (Row #2).

b. To determine road segment length, divide 10,000ft^2 by the recorded width using a calculator. Record length (ft) on field datasheet (Row #2).

c. Record description of the physical features that designate the general start and end points of the road segment on field datasheet (Row #2). Each road segment should be generally identifiable based on field observations and photos so that a new team would be able to relocate the same road segment if desired.

MATERIAL ACCUMULATION AREAS (DATASHEET ROW #3)

Material Accumulation Areas are:
- **Unique to each road segment to represent relative heavy, moderate and light areas for specific segment.**
- **Differentiated by both amount of material and visual assessments of material grain sizes.**

1. Categorize up to 3 accumulation categories for the road segment. **Material accumulation categories** are unique to each road segment. Each road segment can be categorized into no more than 3 material accumulation categories, designated heavy, moderate and light. Typically, a road segment will have 3 distinct material accumulation areas; however, dependant on recent climatic events and road maintenance activities, there may only be one or two distinct areas. Figure 1.22B provides schematics and photos of the general trends of winter material distribution on typical primary and secondary roads.
   a. Consider the entire road segment. Walk the entire perimeter of the road segment (both sides of the road) and inspect all potential condition indicators as you go to determine material accumulation areas.
   b. Identify the dirtiest (heavy) and cleanest (light) areas first, and then evaluate if there is an intermediate (moderate) designation.
   c. If two areas of a road segment visually appear to have the same amount of material on the road, but the dominant grain sizes between the two areas varies greatly, they should be designated as separate material accumulation categories. The area with the higher degree of fines should be designated as the dirtier area (e.g., heavy if considering heavy and moderate areas; moderate if considering moderate and light areas).
      - Differences in the amount of material on the road can be visually determined based on rough estimates of the percent coverage over the road surface, as well as the depth of the material on the road surface.
      - Differences in dominant grain size can be visually estimated. Can individual particles be distinguished? Do some locations appear to have larger grain sizes than other locations? Rub material between fingers: Does it feel gritty or smooth? Can you see your finger print? The use of visual observations detailed below can also be used to delineate area of accumulation.
   d. The user may perform field precision protocols when first using the Road RAM tool to calibrate their visual estimates with measured data.

Road segment facts

2 lanes of traffic

Parking on both sides

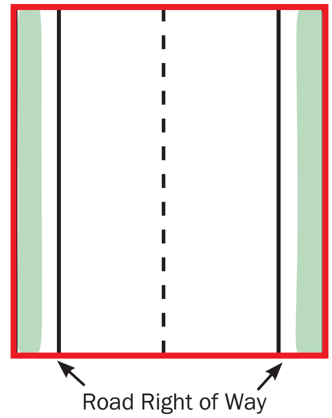
Road segment width

= 40 ft (~13 paces), then

Road segment length

= 250 ft (~83 paces)

Road segment features



Road segment facts

4 lanes of traffic

Parking on both sides

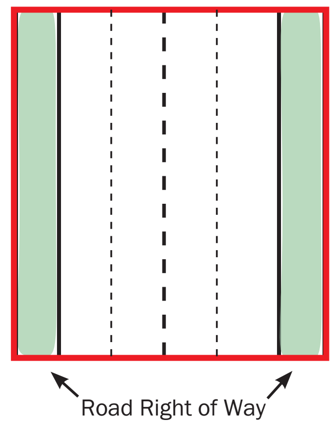
Road segment width

= 65 ft (~22 paces), then

Road segment length

= 150 ft (~50 paces)

Road segment features



Road segment facts

3 lanes of traffic

Bike lane on two sides

Sidewalk on one side

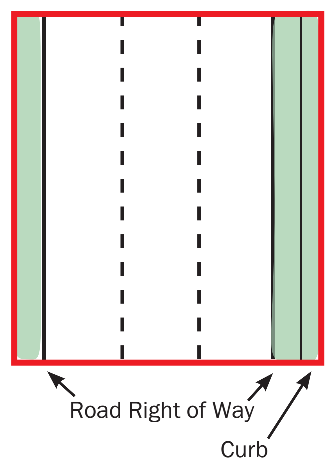
Road segment width

= 50 ft (~17 paces), then

Road segment length

= 200 ft (~67 paces)

Road segment features



These examples also include key road segment features.

LEGEND
Road Segment (10,000 ft^2)
Added Impervious Area

DESIGNED BY

2NDNATURE LLC

TEL: 831.426.9119 FAX: 831.426.7092

www.2ndnaturellc.com

Road segment facts

3 lanes of traffic

Parking on two sides

Sidewalk on both sides

Additional impervious area >20ft (~7 paces); only add 20ft to estimated width

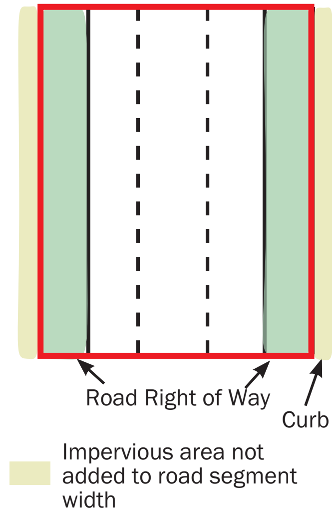
Road segment width

= 60 ft (~20 paces), then

Road segment length

= 165 ft (~55 paces)

Road segment features



Road segment facts

2 lanes of traffic

AC dike on both sides

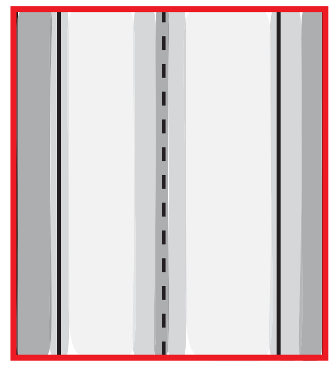
Road segment width

= 30 ft (~10 paces), then

Road segment length

= 330 ft (~110 paces)

Material accumulation distribution



Road segment facts

2 lanes of traffic

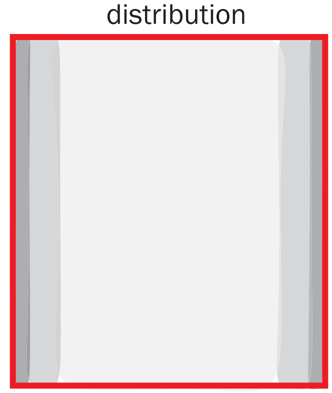
Road segment width

= 20 ft (~7 paces), then

Road segment length

= 500 ft (~167 paces)

Material accumulation distribution



These bottom 2 examples show the material accumulation distribution. See legend on Figure 24A for schematic shown with top photo.

LEGEND	
Road Segment (10,000 ft²)	
Accumulation Category	
Light	Moderate	Heavy

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ROAD SEGMENT EXAMPLES (PAGE 2 OF 2)

FIGURE 1.22B

2. Determine percent distribution of each categorized material accumulation area within the road segment based on the entire area of the road segment. Estimate approximate percentages across both the entire length and width of the road segment to determine overall road segment percentages. Include all contiguous impervious area, such as sidewalks, parking areas, etc., used to estimate road segment width. Where traffic conditions permit, field personnel should pace the width of each accumulation category to determine relative areal distribution percentages. For example, if the road segment width is equal to 12 paces, and the paces for the heavy, moderate and light areas are 2, 4 and 6 respectively, the percent distribution would be equal to 17% heavy, 33% moderate, and 50% light.
3. Record percent distribution of each area on field datasheet in 5% increments. In the example above, the user inputs would be 20% heavy, 30% moderate, and 50% light. If the area is absent from the road segment, enter 0.

DRY MATERIAL COLLECTION PER MATERIAL ACCUMULATION AREA (DATASHEET ROWS #4-6)

The road segment score will inherently be most sensitive to the observation results from the areas that represent the majority of the road segment. The most care should be taken to obtain accurate observations in areas that represent 50% or more of the road segment.

When selecting 1'x1' squares:

- **Field personnel safety is the highest priority. Do not make observations within the flow of traffic.**
- **Material distribution will not be uniform – choose a location that appears to be average in terms of amount of material and grain size distribution.**

1. Choose a representative location in the heavy area for volume measurements and degree of fines observations. The user may perform field precision protocols when first using the Road RAM tool to calibrate their visual estimates with measured data.
2. **Collect dry sample**.
   a. Place 1x1 frame on road surface, ensuring frame maintains square shape.
   b. Use wire brush/toothbrush to dislodge and fine material caked on the road surface.
   c. Use hand broom to sweep all material into dust pan.
      - For road surfaces with poor integrity (i.e., high distribution of cracks and crevices), mine all cracks to extract as much material from road surface within square as possible.
      - Stormwater is very efficient at removing material from road – field personnel must be diligent to remove all available material.
   d. Remove large pieces of organic material (e.g., pine needles, leaves, etc.) from dust pan.
   e. Transfer sample from dust pan to appropriately-sized graduated cylinder using funnel.
   f. Measure volume and select appropriate value range (ml) on field datasheet. Volume should be measured to closest demarcation on the graduated cylinder.

When measuring dry sample:

- **Volume ranges are provided on the field datasheet. Field measurements need to be as precise as the ranges indicate.**
- **The detection limit for dry sample measurements is 0.2 ml. If no material is visible, select 0 on the field datasheet.**

3. **Perform Fines Test** (Figure 1.23).
   a. Locate representative area within the heavy material accumulation area. It should not be the same area where dry sample was collected.
   b. Scrape road surface with a hard edge, using moderate amount of pressure to remove top layer of coarser material from surface.
   c. Ensure fingers are clean prior to performing test. Wet fingers using spray bottle.

NO MATERIAL visible.

YES finger prints visible; SLIMY fingers.

YES finger prints visible; GRITTY fingers.

YES finger prints visible; BOTH gritty and slimy fingers.

NO finger prints visible; BOTH gritty and slimy fingers.

NO finger prints visible; SLIMY fingers.

NO finger prints visible; SLIMY fingers.

Note: Proper technique requires user to rub the finger pads of at least two fingers back and forth across road surface at least 3 times.

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FINES TEST EXAMPLE

FIGURE 1.23

d. Using two fingers and a moderate to high amount of pressure, rub the pad of the fingers back and forth along 6” (approximately the length of a hand) of the road surface at least 2 times (e.g., cover 24”) of road surface.
e. Look at finger surface. Is there material present on fingers? If no material can be seen, record “No Mat’l” on datasheet. If material is present, are fingerprints visible through the material on finger? Record answer (Yes/No) on field datasheet (see Figure 1.23 for photo examples).
f. If material is present on fingers, wet fingers with spray bottle and rub together. Do fingers feel slimy and/or gritty? Record answer (Gritty/Both/Slimy) on field datasheet (see Figure 1.23 for photo examples).

When conducting Fines Test:
- **The greater the amount of fine material on the road surface, the higher the likelihood your fingerprints will be covered and not visible.**
- **Fines are clay-sized particles and in high concentrations will put a slimy film on your finger.**
- **Larger grain sizes are coarser and will feel gritty when your fingers are rubbed together.**

4. **Perform Dust Test** (Figure 1.24).
a. Within unswept 1x1 foot square within the heavy material accumulation area, sweep road surface vigorously (5 sweeps in 3 seconds).
b. Within 2 seconds of sweeping, estimate the height of the resulting dust cloud. If no dust cloud is visible, record “No Cloud”. Height is estimated based on the body parts of the sweeper. It is easiest if one person sweeps, and the other field personnel records observations. Record height (Ankle/Knee/Waist) on field datasheet (see Figure 1.24 for photo examples).
c. Estimate duration of time (in seconds) the dust cloud is visible. Record as either less than or greater than 2 seconds on field datasheet (see Figure 1.24 for photo examples).

When conducting Dust Test:
- **The greater the amount of fine material on the road surface, the larger the resulting dust plume will be and the longer it will remain suspended in the air.**

d. Note: In windy conditions (>10 mph) this observation will be difficult. If dust test cannot be accurately performed, evaluate the air quality conditions due to wind. If no dust is visible in air, enter “No Cloud”. If a few particles of dust are visible, enter “Ankle” and “> 2 seconds”. If a moderate amount of dust is visible, enter “Knee” and “>2 seconds”. If heavy dust is visible (i.e., you can feel it in your eyes and nose), enter “Waist” and “>2 seconds”.

5. Repeat above dry material protocols in the moderate and light material accumulation areas on road segment, as necessary, and record answers and measured volumes on the field datasheet (Datasheet Rows #5 and #6). For each road segment, 3 dry material sample collections, 3 fines tests, and 3 dust tests are conducted, unless a material accumulation category is absent (0% distribution in Datasheet Row #3).

ANKLE high; > 2 seconds in air

WAIST high; > 2 seconds in air

Note: Proper technique requires user to sweep 1’x1’ square area briskly (3 times in 5 seconds) and immediately measure height of resulting dust cloud and time dust remains suspended.

POPULATE DATABASE

1. On website banner, go to “Forms” -> “Step 4B Field Observations” (Figure 1.25).
2. Select appropriate road segment from dropdown list.

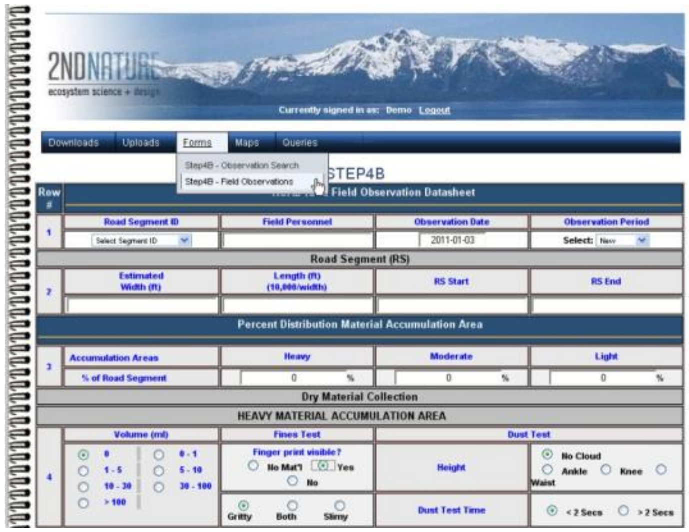


Figure 1.25. STEP 4B Data Entry Form.

3. Enter the field personnel and observation date.
4. Determine the observation period. To group observations made during the same time span, the database creates a unique observation period ID.
   a. For the first record entered for an observation period, select “New.” The database will generate a new observation period based on the observation date.
   b. For all remaining records for an observation period, select the appropriate observation period ID from the dropdown. Note: the most recently created observation period is listed first.
5. Click “Submit” to submit the field observation data and generate a road segment score. Click “Reset” to clear form without submitting data to the database. Resolution to common data entry errors are provided in *Part IV: Troubleshooting – Database Forms*.
6. A pop up window provides the calculated road segment score. Click “OK” to accept and move to a blank datasheet. Click “Cancel” to return to the current field datasheet.

REVIEW PREVIOUSLY ENTERED DATA

1. On website banner, go to “Forms” -> “Step 4B Observation Search” (Figure 1.26).
2. Select appropriate road segment location from list on left. Confirm road segment location on map.
3. Select observation period from list on right.
4. Choose “Edit” to view populated datasheet and make edits to data. The populated datasheet will appear. Follow directions above (Populate Database) to edit and resubmit data.
5. Choose “Delete” to delete the data record. (Warning: This cannot be undone.)

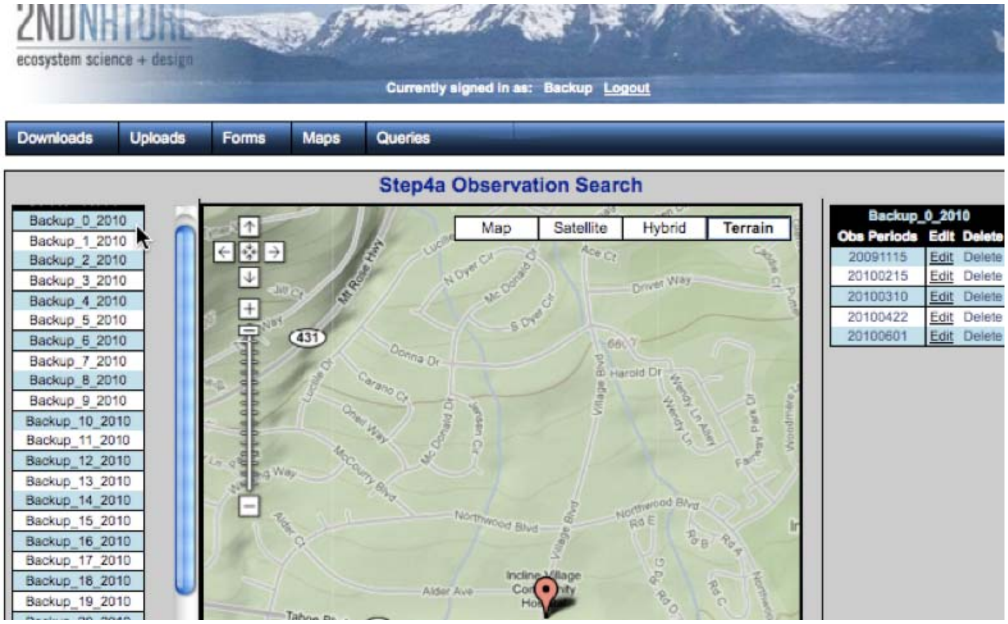


Figure 1.26. View Previously Entered STEP 4B Data.

ADDITIONAL STEP 4B GUIDANCE

TEMPORAL CONSIDERATIONS FOR OBSERVATIONS

Road RAM observations MUST be made when the road surface is dry to improve field data collection precision and comparisons across sites and observation periods. Since road condition is high sensitive to winter road abrasive applications, road conditions will be at seasonal lows immediately following winter storm events. If Road RAM is applied within 1-2 weeks following the most recent winter storm event this provides ample time for pollutant recovery and source control by the responsible jurisdictions.

Road class assumes roads of the same class are maintained in a similar manner by the jurisdiction. The standard deviation of observations will be greater if roads maintenance activities are inconsistent across similarly classed roads. Consider the typical frequency of pollutant recovery actions across the entire jurisdiction. For example, if a jurisdiction typically takes 2 weeks following an abrasive application to complete sweeping of all “Moderate” roads (SE = Y), then observations should be made no sooner than 2 weeks following an event. There are also seasonal considerations for users who wish to compare Road RAM results to Crediting Program inputs (see *Part II: Alignment with Crediting Program*).

ROAD RAM STEP 5 – OBTAIN ROAD RAM SCORES

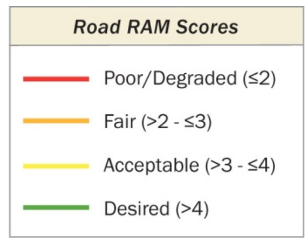
STEP 5 OVERVIEW

The user obtains temporally discrete road segment (spatially discrete) and Road RAM (spatially extrapolated) Road RAM scores within an area of interest (Table 1.8). The STEP 5 outputs are database generated spatial displays and tabular outputs of the Road RAM scores for road segments and road classes within an area of interest.

Table 1.8. GIS analysis and database interaction for Road RAM STEP 5.

Road RAM STEP #	Road RAM STEP Name	GIS Analysis	Online Database	Frequency of STEP completion
5	Obtain Road RAM SCORE	n/a	View Map View Query	Seasonally

PROTOCOLS



Time Required: 5-10 minutes

Equipment Required:

- Computer equipped with internet access

VIEW ROAD SEGMENT RESULTS

1. View Road Segment Results Map. This map displays the road segment scores for a selected observation period. The road segment marker is colored based on the road segment score (as shown above).
   a. Go to “Maps” -> “STEP 5 Road Segment Scores.”
   b. Select appropriate observation period from drop down list on left and click “Click to Submit.”
   c. Road Segment Scores are shown for selected observation period (Figure 1.27).

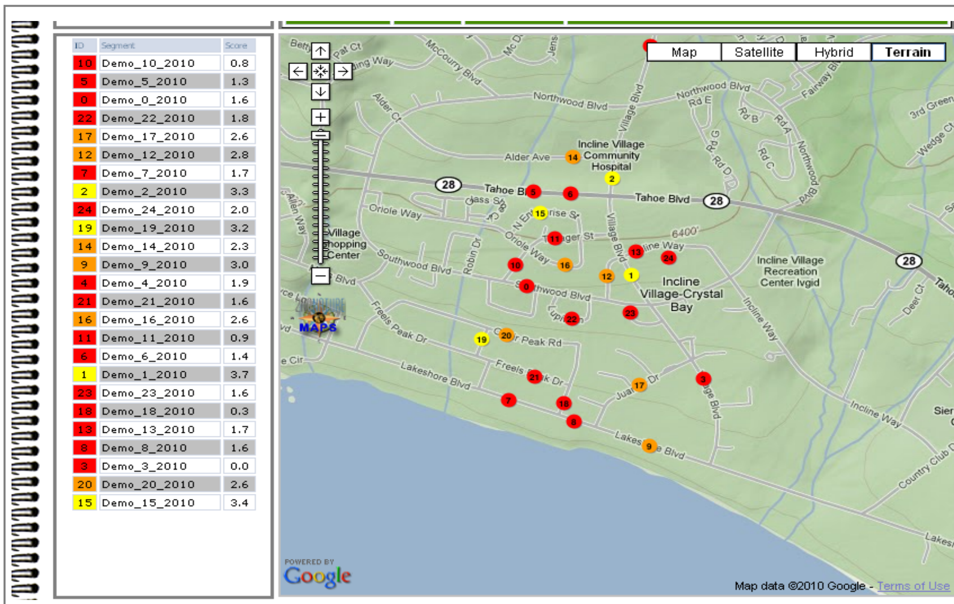


Figure 1.27. View STEP 5 Road Segment Score Map.

2. View Road Segment Results Query. This query summarizes road segment scores by observation period.
   a. Go to “Queries” -> “STEP 5 Road Segment Scores”
   b. Select the appropriate observation period from the drop down list. Click “Select”.
   c. A table of Road Segment Scores is generated for the selected observation period (Figure 1.28).

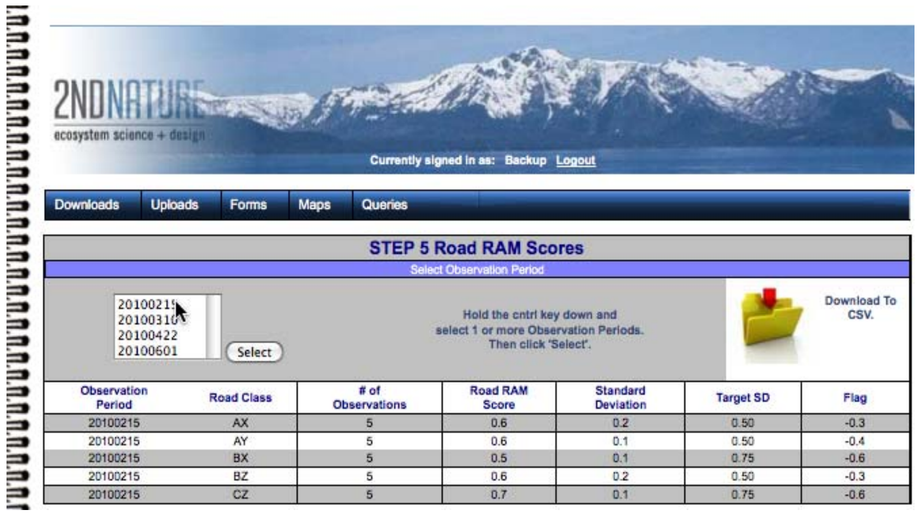


Figure 1.28. View STEP 5 Road Segment Score Query.

VIEW ROAD RAM RESULTS

1. View Road RAM Results Map. This map displays the spatially extrapolated Road RAM scores for a selected observation period by road class. The road is colored based on the Road RAM score (as shown above).
   a. Go to “Maps” -> “STEP 5 Road RAM Scores” (Figure 1.29).
   b. Select the appropriate area of interest from the drop down list.
   c. Select the appropriate observation period from the list. Click “Select”.
   d. Road RAM Scores are shown for the selected area of interest and observation period.

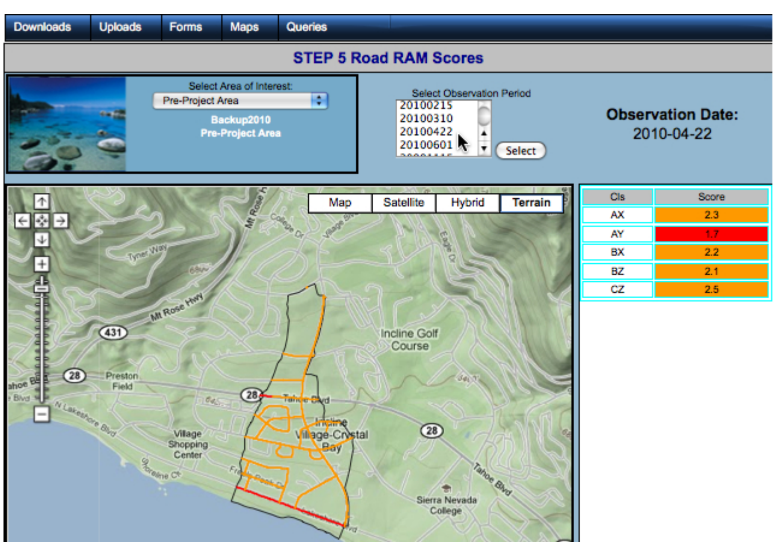
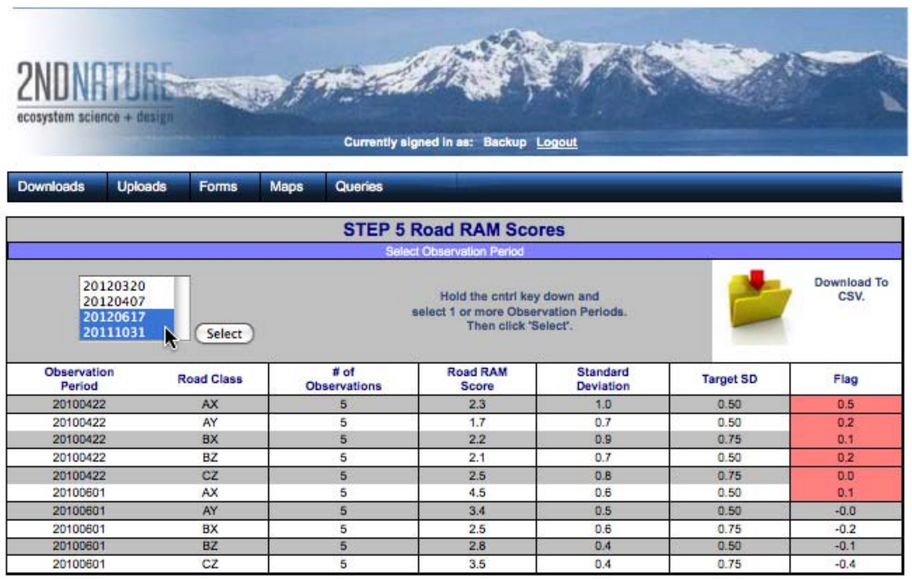


Figure 1.29. View STEP 5 Road RAM Score Map.

2. View Road RAM Results Query. This query summarizes the spatially extrapolated Road RAM scores by observation period by road class.
   a. Go to "Queries" -> "STEP 5 Road RAM Scores".
   b. Select the appropriate observation periods from the list. Multiple observation periods can be selected by holding down the control key while selecting observation periods. Click "Select".
   c. A table of Road RAM scores is generated for the selected observation period(s) (Figure 1.30). See *Additional Guidance* for discussion on standard deviation (SD).



Observation Period	Road Class	# of Observations	Road RAM Score	Standard Deviation	Target SD	Flag
20100422	AX	5	2.3	1.0	0.50	0.5
20100422	AY	5	1.7	0.7	0.50	0.2
20100422	BX	5	2.2	0.9	0.75	0.1
20100422	BZ	5	2.1	0.7	0.50	0.2
20100422	CZ	5	2.5	0.8	0.75	0.0
20100601	AX	5	4.5	0.6	0.50	0.1
20100601	AY	5	3.4	0.5	0.50	-0.0
20100601	BX	5	2.5	0.6	0.75	-0.2
20100601	BZ	5	2.8	0.4	0.50	-0.1
20100601	CZ	5	3.5	0.4	0.75	-0.4

Figure 1.30. View STEP 5 Road RAM Score Query

ADDITIONAL STEP 5 GUIDANCE

ROAD RAM SCORE STANDARD DEVIATION ANALYSIS

STEP 5 score results include the standard deviation calculation for Road RAM scores by road class for one observation period. It is a general good practice for users to compare the standard deviation the Road RAM score across road classes and observation periods to gain the most value from the Road RAM tool. If the calculated standard deviations are greater than 0.5 for a series of road segment scores, the user should identify the outlier values and use the following process to improve the precision of future observations.

> **Crediting Program**
> - **The Crediting Program recommends target standard deviations by road class for calibration and check up years (see *User Part II: Alignment with Crediting Program*).**

1. Road classification error: Verify road classification is representative of actual practices implemented by road maintenance personnel.
   - Consider the definitions of "Intensive", "Moderate" and "Rarely to Never" for both abrasive application priority and sweeping effectiveness. Should these definitions be refined to more accurately depict actual practices?
   - Are specific roads mis-classified? Consider on a neighborhood scale.
2. Road condition changes: Verify that no maintenance practices, rain events or other actions that may change road condition have occurred during the observation period of roads of the same class.

- o Runoff events during a observation period would cause road segments observed following the event to be in better condition than those observed prior to the event.
- o For similarly classed roads, more recently swept roads will be in better condition than those roads that have not been recently swept.
- o Similarly, if abrasive have been applied more recently in one location than another, the road will be in poorer condition. This may occur if a storm event was unevenly distributed across a jurisdiction (e.g., one area got more significant snowfall than another).

3. Observation error: Were observations across segment of the same class during the observation period completed by different field personnel? Verify field techniques are consistent with Road RAM protocols (STEP 4B) and that all field staff are appropriately trained on the use of the Road RAM protocols.
4. Unrepresentative segments: Consider other attributes of individual road segments such as road shoulder condition, road surface integrity, or other potential localized sources or sinks of pollutants to the segment that make it potentially not representative of other segments of the same class. Increasing sample size will reduce the statistical influence of individual outliers on the SD of the class.

ROAD RAM STEP 6 – ANALYZE RESULTS

STEP 6 OVERVIEW

> **RULES**
> - **STEP 6 temporal analyses include seasonal and annual averages, and temporally-weighted scores.**
> - **STEP 6 spatial analyses depend on completion of STEPs 1-3.**

The user can analyze the field observation data on a variety of spatial and temporal scales, based on the data entered in STEPs 1-4. The analyses are purposefully designed to be flexible to allow the user to implement Road RAM for a range of data analysis goals, including alignment with the Crediting Program. A range of potential analyses are discussed in *Road RAM Technical Document Chapter 10: Application of Road RAM Data and Results*.

The STEP 6 outputs are spatial displays and tabular outputs based on the chosen analyses (Table 1.9).

Table 1.9. GIS analysis and database interaction for Road RAM STEP 6.

Road RAM STEP #	Road RAM STEP Name	GIS Analysis	Online Database	Frequency of STEP completion
6	ANALYZE Results	n/a	View Map View Query	Seasonally

The built-in STEP 6 analysis functionality of Road RAM Database v.1 is limited to annual Road RAM score calculations. However, users can export STEP 5 road segment and Road RAM scores to Excel to perform any range of analyses outside of the database, including joining the data to the STEP 3 GIS shapefile attribute table to display results by road attribute.

PROTOCOLS

Time Required: Depends on the level of analysis desired

Equipment Required:

Computer equipped with internet access

VIEW ANNUAL ROAD RAM RESULTS

1. View Annual Road RAM Scores Query. This query generates annual scores for an area of interest based on the season weighting presented in Table 1.10.

   Table 1.10. Seasonal weighting of observation period Road RAM scores to generate Annual Road RAM Score. (See *Part II: Alignment with Crediting Program* for discussion of technical justification.)

Season (months)	Percent (%) weighting
Fall (Oct-Dec)	20%
Winter (Jan-Feb)	20%
Late Winter/Early Spring (March-April)	40%
Spring (May-June)	20%
Summer (July-Sept)	0%

   a. Go to “Queries” -> “STEP 6 Annual Scores.”
   b. Select the appropriate water year from drop down list on left and click “Click to Submit.”
   c. Annual Road RAM scores are shown for selected observation period (Figure 1.31).

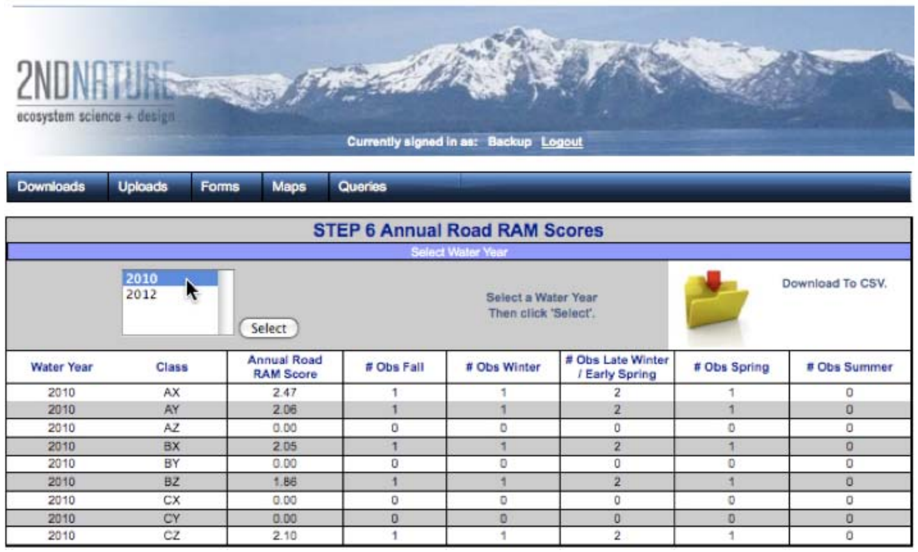


Figure 1.31. View STEP 6 Annual Road RAM Score Query.

EXPORT RESULTS

1. Export STEP 5 Road Segment or Road RAM Score tabular results to MS Excel. *Road RAM Technical Document Chapter 10: Application of Road RAM Data and Results* provides numerous potential analysis scenarios.
   a. Go to "Queries" -> "STEP 5 Road Segment Scores" or "STEP 5 Road RAM Scores" or "STEP 6 Annual Road RAM Scores."
   b. Select the appropriate observation period and/or area of interest and/or water year from the drop-down list. Click "Select".
   c. Click on the "Download to CSV" icon (see Figure 1.31) and save the file to the appropriate location on your computer.

PART II: ALIGNMENT WITH CREDITING PROGRAM

The Road RAM tool provides a wide array of valuable data and standardized protocols to evaluate and track road condition across the Tahoe Basin overtime. The *Road RAM Technical Document Chapter 10: Applications of Road RAM Data and Results* provides a long list of potential analyses and benefits to improve road maintenance practices and reduce pollutant loading from Tahoe Basin roads. In addition, the Road RAM tool will provide jurisdictions with a tool to meet future Lake Clarity Crediting Program (Crediting Program) requirements.

User Manual Part II: Alignment with Crediting Program outlines how the Road RAM tool can be used to meet Crediting Program observation and reporting requirements. For each road class the Crediting Program recommends a minimum number of road segments (STEP 4A – Select ROAD SEGMENTS), a minimum number of observations per observation period (STEP 4B – Conduct FIELD EVALUATIONS), and a target standard deviation for road segment results (STEP 5 – Obtain RAM SCORE). To compare Road RAM results to the annual expected condition scores established in the Catchment Credit Schedule submitted to the regulatory agencies, road class results must be temporally integrated to calculate an annual score (STEP 6 – ANALYZE Results).

LEVEL OF EFFORT

By striking the right balance, Road RAM results can provide valuable information to increase the effectiveness of maintenance activities and represent annual road conditions, without diverting significant effort from effective maintenance activities. In an attempt to attain this balance, a two-tiered approach is presented to choosing the number of road segments per observation period and the number of observation periods during a water year. This two tiered system includes significant effort to establish consistency of results every fifth year (**calibration years**), while efficiently using information to perform quality assurance checks with minimal effort in the interim four years (**check up years**).

CALIBRATION YEARS

During the first year an urban jurisdiction is using the Road RAM and every fifth-year thereafter, a large number of field observations performed at many different times throughout the year is necessary to calibrate the abrasive application, sweeping and other pollutant control practices that result in road conditions that meet expectations. Low statistical variation among field observations should be achieved during calibration years. During these years, extra attention should be paid to ensure maintenance plans are realistic and can result in expected conditions.

During calibration years, five (5) Road RAM observation periods should be distributed during the year (discussed below). The level of effort required for each observation period should not be more than 5 full time days of field time for 2 staff working together. The total estimated level of effort during calibration years is expected to be 16% of a full time equivalent (FTE) position, including field time, 1 day of staff time per observation period for data entry, analysis and review and 2 days for annual reporting.

CHECK UP YEARS

Once a jurisdiction’s implementation plans and operational activities are calibrated with Road RAM scores, a reduced number of observations focused on the most critical times of the year is sufficient to ensure that maintenance plans are being implemented effectively to achieve expected conditions. Because of the reduced number of observations, moderate statistical variability is acceptable during check-up years. However, high variability is potentially an indication of a performance problem that should be investigated and addressed.

During check-up years, three (3) observation periods should be targeted during critical winter and early spring periods as discussed below. The level of effort required for each observation period should not be more than 3 full time days of field time for 2 staff working together. The total estimated level of effort during calibration years is expected to be 8% of a full-time-equivalent (FTE) position, including field time, 1 day of staff time per observation period for data entry and management, and 2 days for annual reporting.

MINIMUM NUMBER OF ROAD SEGMENTS AND TARGET STANDARD DEVIATION

When the spatial extrapolation of road segment results to the respective road class is desired a minimum number of road segment observations for each road class is recommended based on the potential of each road class to be in relatively poor condition and the target precision of road segment scores obtained. By striking the right balance, Road RAM results can provide valuable information to increase the effectiveness of maintenance activities and represent average annual conditions, without diverting attention from the implementation of effective maintenance actions.

The recommended minimum number of road segments observed in each observation period balances the need to accurately characterize the conditions of roads in each road class with the practical need to limit the amount of staff time required to complete field observations. Given limited time and resources, RAM observations will focus on road classes that are more likely to be in relatively poor condition, and thus subjected to relative high sources of abrasives. Tables 2.1 and 2.2 provide the recommended minimum number of road segments for each road class (STEP 4A) and the target standard deviation of road segment scores (STEP 5) related to each road class for both calibration and check up years. The values in Tables 2.1 and 2.2are based on the expected relative importance of each road class based on road maintenance practices and potential for poor road conditions and associated downslope water quality impacts. A greater number of road segments per road class are required during the calibration year, as well as a lower target standard deviation of the road segment scores per road class.

TABLE 2.1. Calibration year number of road segments and target standard deviation by road class.

Sweeping Effectiveness	**Abrasive Application Priority**		
	Intensive (A)	Moderate (B)	Rarely to Never (C)
Intensive (X)	15 /±0.5	12 /±0.75	8 /±1.0
Moderate (Y)	15 /±0.5	12 /±0.75	8 /±1.0
Rarely to Never (Z)	15 /±0.5	15 /±0.5	12 /±0.75

TABLE 2.2. Check-up year number of road segments and target standard deviation by road class.

Sweeping Effectiveness	**Abrasive Application Priority**		
	Intensive (A)	Moderate (B)	Rarely to Never (C)
Intensive (X)	8 /±0.6	5 /±0.9	3 /±1.3
Moderate (Y)	8 /±0.6	5 /±0.9	3 /±1.3
Rarely to Never (Z)	8 /±0.6	8 /±0.6	5 /±0.9

FREQUENCY OF OBSERVATIONS OVER A WATER YEAR

Road RAM observation can be conducted as frequently as the user desires and increased observation periods will increase confidence in the road condition results as they are extrapolated to an annual average. However, when the Road RAM is being used by jurisdictions as a Crediting Program reporting tool, a minimum number of observation periods have been determined. Table 2.3 presents the minimum number of Road RAM observation periods necessary per season for calibration and check up years, based on the annual time step defined as one water year (October 1 – September 31). The recommended temporal distribution of annual Road RAM observations proportionally weights the road conditions in the late winter/early spring as the priority season. The timing of observations recommended in Table 2.3 provides information to inform road maintenance decisions and characterize road conditions before periods with expected runoff events that transport pollutants to surface waters and wash roads clean of pollutants in the process.

Additional observations may be made and incorporated into the annual summary and temporal integration as desired, but the *Road RAM Database* will integrate annual Road RAM results based on the weighting provided in Table 2.3.

TABLE 2.3. Minimum Road RAM observation periods by season to obtain the annual RAM score over a single year. The Road RAM implements a weight of observations per season based on the annual weighting contributions identified.

Season (months)	CALIBRATION YEAR Minimum # of Observation Periods (% weighting)	CHECK UP YEAR Minimum # of Observation Periods (% weighting)	Specific Timing and Rationale
Fall (Oct-Dec)	1 (20%)	0 (0%)	Observations should occur prior to first winter rain event. Stormwater runoff event probability of occurrence is high.
Winter (Jan-Feb)	1 (20%)	1 (33%)	Road condition expected to be at annual low when abrasive application occurs frequently. Larger stormwater runoff event probability of occurrence is low, typical runoff is gradual localized snowmelt.
Late Winter/ Early Spring (March-April)	2 (40%)	2 (66%)	Air temperature increases and snow fall frequency decreases, providing opportunity for aggressive sweeping. Stormwater runoff event probability of occurrence increases to moderate/high. All observations must be conducted prior to first significant (1 in/12hr) rainstorm event washing roads clean.
Spring (May-June)	1 (20%)	0 (0%)	Snowmelt and spring snow and rain events with frequent runoff. Temperatures provide opportunity for sweeping. Probability of roads being washed by a spring rain event is high.
Summer (July-Sept)	0 (0%)	0 (0%)	Road conditions expected to be at annual high due to extended duration since last abrasive applications and road cleaning by spring/summer rains.

The timing of RAM observation periods by jurisdictions could raise concerns about the potential tradeoff between performing the Road RAM versus doing necessary maintenance. It is important to understand that the Road RAM can be used at many time scales but that road conditions are assumed to change slowly between condition-changing events such as precipitation, abrasive application or sweeping. Thus is it not necessary to consider if a jurisdiction should choose maintenance or the Road RAM before/after specific events: timing of the Road RAM is flexible and should not preclude maintenance activities. However, the best-condition roads are observed in urban jurisdictions with maintenance plans that minimize abrasive application magnitudes and frequency and call for recovery of abrasives as soon as practicable after conditions and workloads allow.

PART III: GIS COMMANDS

Throughout this document several GIS commands are referenced repeatedly. To improve the readability of this document, protocols associated with these commands are synthesized here instead of being repeated throughout the document. Commands are presented alphabetically. The GIS commands described below were outlined using ArcGIS 9.3. Earlier versions of the program may contain slight differences in toolbox and command structure. However, the specific tool can be located in the user's ArcGIS version by searching the Help menu.

ADD FIELD TO ATTRIBUTE TABLE

1. Right click layer and select "Open attribute table."
2. Click "Options" button on lower right.
3. Select "Add field…"
4. In dialog box:
    a. Enter field name.
    b. Select appropriate field data type from drop down list.
    c. Enter recommended precision and scale values as necessary.
5. Click "Ok."

APPLY SYMBOLOGY LAYER

The Road RAM tool provides symbology layers for STEP 2 and STEP 3 shapefiles to standardize spatial presentation.

1. Right click layer and select "Properties..."
2. Navigate to "Symbology" tab.
3. Click "Import..." at the top of the dialog box.
4. In the dialog box:
    a. Select "Import symbology definition from another layer in the map or from a layer file."
    b. Click the folder icon to browse to the appropriate *.lyr file and click "Add."
    c. Select "Complete symbology definition" to import the complete symbology.
    d. Click "Ok."
5. The layer should now display with the appropriate Road RAM symbology.

Note: If GIS will not apply the symbology layer, check to ensure that all column headers and field values are consistent with the Road RAM protocols.

CALCULATE GEOMETRY

1. Right click layer and select "Open attribute table."
2. Select column header of appropriate field.
    - If field does not exist, follow "Add Field to Attribute Table" protocols above.
3. Select column header, right-click and select "Calculate Geometry."
4. In dialog box:
    a. Select appropriate property (e.g., Length, Area, etc.).
    b. Select coordinate system (default to coordinate system of data source).
    c. Select appropriate units (e.g., Feet, Acres, etc.)
    d. Click "Ok."
5. Geometry calculations will appear in column for each record.

CLIP FEATURE

1. Open ArcToolbox.
2. Locate “Analysis Tools” -> “Extract” -> “Clip.”
3. In dialog box:
    a. “Input Features” is the layer to be clipped (e.g., Roads).
    b. “Clip Features” is the layer that will be used to clip the input feature (e.g., STEP 1 area of interest).
    c. “Output Feature Class” is the name and location of the new layer.
    d. Click “Ok.”
4. New layer appears on map.

CONCATENATE FIELDS

1. Right click layer and select “Open attribute table.”
2. Select column header of appropriate field.
    a. If field does not exist, follow “Add Field to Attribute Table” protocols.
3. Select column header, right-click and select “Field Calculator.”
4. In dialog box:
    a. In lower box, enter fields to calculate new field.
        - Formula is [field1] + [field2]
    b. Click “Ok.”
5. Calculations appear in attribute table field.

COPY BASELAYER

1. Right click “RoadRAMInventory” shapefile and select “Data” -> “Export Data.”
2. In dialog box:
    a. Export “All features.”
    b. Use the same coordinate system as: “this layer’s source data.”
    c. Output shapefile or feature class: navigate to appropriate folder and save file based on recommended naming convention.
    d. Click “Ok.”
3. Click “Yes” to add exported data to the map as a layer.

CREATE SHAPEFILE

1. Open ArcCatalog.
2. Navigate to the appropriate location on computer.
3. Right-click folder and select “New” -> “Shapefile.”
4. In dialog box:
    a. Provide name.
    b. Select appropriate “Feature Type” from drop down list (point, polyline or polygon).
    c. Click “Edit” to assign spatial reference.
        - Recommended projected coordinate system is NAD_1983_UTM_Zone_10N.
    d. Click “Apply”, then “Ok.”

EDIT FIELDS IN ATTRIBUTE TABLE

1. Start Editing Session.
   a. Show Editing Toolbar.
      - Under Main Toolbar, select "View" -> "Toolbars" -> "Editor."
   b. In Editor Toolbar, select "Editor" -> "Start Editing."
      - If necessary, in Start Editing dialog box, choose appropriate source.
      - Note: Highlight source file until appropriate layer is displayed in lower half of dialog box.
2. Right click layer and select "Open attribute table."
3. Select feature to edit.
   - Highlight corresponding row in attribute table, or
   - Use select feature on map.
4. Click on field in attribute table and enter new information.
5. Save Edits. Click "Editor" -> "Save Edits." *Note: once the edit session is saved, your edits cannot be undone.
6. Stop Editing. Click "Editor" -> "Stop Editing."

EDIT FEATURE

1. Start Editing Session.
   a. Show Editing Toolbar.
      - Under Main Toolbar, select "View" -> "Toolbars" -> "Editor."
   b. In Editor Toolbar, select "Editor" -> "Start Editing."
      - If necessary, in Start Editing dialog box, choose appropriate source.
      - Note: Highlight source file until appropriate layer is displayed in lower half of dialog box.
2. Select appropriate shapefile as target.
   a. In Editor Toolbar, go to "Target:" and select appropriate layer from drop down list.
3. Select "Create New Feature" task.
   a. In Editor Toolbar, go to "Task:" and select from drop down list.
4. Click the Sketch tool (pen).
5. Draw shape.
   - For points, click to create one point. Each click creates a new point feature.
   - For lines, click to draw points along line. Double click on last point to finish sketch and create line.
   - For polygons, click to create vertices. Double click on last vertex to finish sketch and create polygon.
   - Note: To create polygons with shared boundaries, use "Autocomplete Polygon" task.
6. Note: Features can also be deleted.
   a. Select feature using Select tool.
   b. Click "Delete."
7. Save Edits. Click "Editor" -> "Save Edits."
8. Stop Editing. Click "Editor" -> "Stop Editing."

EXPORT ATTRIBUTE TABLE AS *.TXT FILE

1. Right click layer and select "Open attribute table."
2. Click "Options" button on lower right.
3. Select "Export…"
4. In dialog box:
   a. Export "All records."

   b. Output table. Navigate to appropriate folder and save file based on recommended naming convention. Save as text file (*.txt).
   c. Click "Ok."
5. In dialog box, choose to display or not display ("Yes" or "No") the table in the current map, as desired.

EXPORT SHAPEFILE TO *.KMZ

Note: When GIS creates a KMZ file, only the Primary Display Field (see below) is exported. If your version of ArcGIS does not have this capability to export a shapefile to KMZ, there are various converters available on the internet. Check http://freegeographytools.com or search "shapefile to KMZ converter" in your search engine.

1. Zoom to layer to be exported.
   a. Select layer.
   b. Right-click and choose "Zoom to Layer."
   c. Ensure the layer to be exported is turned on in the table of contents.
2. Open ArcToolbox.
3. Choose "Conversion Tools" -> "To KML" -> "Layer to KML." Note: Although the GIS terminology is KML, the file is actually saved as a *.kmz file.
4. In dialog box:
   a. Select layer to be exported in "Layer."
   b. Name appropriate location and file for KML file under "Output File." Click folder on right as necessary.
   c. Enter current map scale as "Layer Output Scale." Note: Leave out preceding "1:" and enter only the scale value.
5. Click "Ok."
6. To check that this step was performed correctly, open file in Google Earth.
   a. Start Google Earth program
   b. Open *.kmz file using "File" -> "Open."
      - Map should zoom to spatial extent of file.
      - Click on "+" fields in "Places" directory to view unique identifiers. Verify these are the correct data.

FIELD CALCULATOR

1. Right click layer and select "Open attribute table."
2. Select features for calculation.
   - To calculate field for all features, select column header of appropriate field.
   - To enter values for a subset of features, select records by highlighting rows in attribute table or using select tool.
3. Open field calculator.
   a. Select column header, right-click and select "Field Calculator."
   b. If field does not exist, follow "Add Field to Attribute Table" protocols above.
4. Calculate fields based on formula.
   a. Enter formula in lower half of dialog box.
      - Double-click fields from upper box to select and use in calculation.
      - Text values entered in quotes (" ").
   b. Click "Ok."
5. Calculations appear in attribute table field.

INTERSECT FEATURES

Note: The optional STEP 2 road attributes that map characteristics for the road shoulders (e.g., Road Shoulder Condition and Road Shoulder Connectivity) cannot be intersected with the attributes mapped for the road surface.

1. Open ArcToolbox.
2. Choose “Analysis Tools” -> “Overlay” -> “Intersect.”
3. In dialog box:
    a. “Input Features” are the layers to be intersected (e.g., Roads).
        - Note: With some licenses, only 2 layers may be intersected at a time. In this case, the intersect function will have to be repeated step by step for each layer that needs to be intersected. Multiple intermediate shapefiles will need to be created to generate the final shapefile.
        - Note: Be sure to clear all selected features prior to running intersection.
    b. “Output Feature Class” is the name and location of the new layer.
    c. Choose “ALL” from drop down list for “Join Attributes.”
    d. Choose “INPUT” from drop down list for “Output Type.”
    e. Click “Ok.”
4. New layer appears on map.
5. After each intersection, delete fields in the attribute table to reduce confusion and duplicated fields.
    a. Right click layer and select “Open attribute table.”
    b. Select column header.
    c. Right click and select “Delete Field.”
    d. Click “Yes” to confirm delete field.

MERGE FEATURES

1. Start Editing Session.
    a. Show Editing Toolbar.
        - Under Main Toolbar, select “View” -> “Toolbars” -> “Editor.”
    b. In Editor Toolbar, select “Editor” -> “Start Editing.”
        - If necessary, in Start Editing dialog box, choose appropriate source.
        - Note: highlight source file until appropriate layer is displayed in lower half of dialog box.
    c. Click “Ok.”
2. Select appropriate shapefile as target.
    a. In Editor Toolbar, go to “Target:” and select appropriate layer from drop down list.
3. Click the Edit tool (black arrow).
4. Click the lines you want to merge. Hold shift key to select multiple features. Re-click to deselect.
5. Merge the line:
    a. Select “Editor” -> “Merge.”
    b. Select the line with the attributes to use for the merged feature.
        - Highlighted feature in dialog box is highlighted on map.
        - *Edit fields in attribute table* as necessary.
6. Save Edits. Click “Editor” -> “Save Edits.”
7. Stop Editing. Click “Editor” -> “Stop Editing.”

MERGE SHAPEFILES

1. Open Arc Toolbox.
2. Select “Data Management Tools” -> “General” -> “Merge.”
3. In dialog box:

   a. Under “Input Datasets” add shapefiles to be merged.
      - Note: You can add shapefiles to dialog box using plus symbol on right, or by dragging file directly into dialog box.
   b. Under “Output Datasets”, name output file and save in appropriate file on computer.
   c. Click “Ok.”
4. Add shapefile to ArcMap.

PRIMARY DISPLAY FIELD

1. Right click layer and select “Open attribute table.”
2. Right click appropriate field header (e.g., “Name”) and select “Properties…”
2. Under Display, check box for “Use Field as Primary Display Field.”
3. Click “Ok” and close attribute table.

SPATIAL JOIN

1. Open Arc Toolbox.
2. Select “Analysis Tools” -> “Overlay”-> “Spatial Join.”
3. In dialog box:
   a. Under “Target Features”, select the shapefile with the spatial information to keep.
   b. Under “Join Features”, select the shapefile with information to be joined to the target feature.
   c. Under “Output Feature Class”, name output file and save in appropriate file on computer.
   d. Under “Join Operation”, select “Join_One_to_One.”
   e. Ensure “Keep All Target Features” box is checked.
   f. Under “Match Option”, select “Closest.”
   g. Under “Search Radius”, enter distance value. This will depend on the accuracy at which the target feature was mapped. Enter a value based on the margin of error associated with the mapping.
   h. If desired, enter field name under “Distance Field Name” to QAQC mapping error of target features.
   i. Click “Ok.”
4. Add shapefile to ArcMap and apply appropriate symbology layer file. See above for protocols.

SPLIT FEATURES

1. Start Editing Session.
   a. Show Editing Toolbar.
      - Under Main Toolbar, select “View” -> “Toolbars” -> “Editor.”
   b. In Editor Toolbar, select “Editor” -> “Start Editing.”
      - If necessary, in Start Editing dialog box, choose appropriate source.
      - Note: highlight source file until appropriate layer is displayed in lower half of dialog box.
   c. Click “Ok.”
2. Select appropriate shapefile as target.
   a. In Editor Toolbar, go to “Target:” and select appropriate layer from drop down list.
3. Click the Edit tool (black arrow).
4. Click the line you want to split.
5. Split the line by either:
   a. Click the Split tool on the Editor toolbar, or
   b. Select “Editor” -> “Split.”
6. Save Edits. Click “Editor” -> “Save Edits.”
7. Stop Editing. Click “Editor” -> “Stop Editing.”

PART IV: TROUBLESHOOTING

A Road RAM Technical Support Forum is available for users to post questions and gain advice on all aspects of the tool. Additionally, questions may be sent to the Database Administrator. Contact information for both is available on the website.

DATABASE SETUP

I CANNOT ACCESS THE DATABASE

- Ensure you have a proper internet connection.
- Ensure you have entered the website name correctly: www.tahoeroadram.com
- Report problem to Database Administrator.

I CANNOT LOG ON

- User names and passwords are case sensitive. Check that Caps Lock is not enabled.
- Report problem to Database Administrator.

I NEED TO CHANGE MY USER NAME

- User name changes should be kept to a minimum as some of the data relationships within the tool are sensitive to the name. If you need to change your user name, please contact the Database Administrator.

I NEED TO CHANGE MY PASSWORD/I FORGOT MY PASSWORD

- In Road RAM v1, there is no online service for having your password sent to you automatically. Please contact the Database Administrator for any issues with your password.

GIS ANALYSIS

In general, it is not the intent of Road RAM to provide detailed support for GIS analysis. GIS protocols have been provided in *Part III: GIS Commands* to guide the user through Road RAM-specific protocols. However, for GIS-specific issues, the user should contact ArcGIS customer support, through use of the Help Menu or various online support forums.

I CANNOT INTERSECT MY ROAD ATTRIBUTES

- Certain optional STEP 2 road attributes can be mapped for the road shoulders (e.g., Road Shoulder Condition and Road Shoulder Connectivity) and therefore result in 2 lines per road. However, the STEP 2 Road Inventory shapefile and resulting STEP 2 and STEP 3 road attributes (e.g., Road Risk, Road Surface Integrity, Abrasive Application Priority, Sweeping Effectiveness, and Road Class) are mapped for the road surface and result in only 1 line per road. Therefore, the road shoulder layers cannot be interested with the other road attributes. Attempting to do so will result in a blank GIS shapefile with no data.

DATABASE DOWNLOADS

I DO NOT SEE THE FILE NAME I NEED TO DOWNLOAD

- Contact the Database Administrator.

I DO NOT SEE MY DOWNLOADED FILE

- Make sure you are looking at the right place on your computer. Often the default location for downloads is on the C drive, under "My Documents".

I DON'T SEE THE WEBSITE BANNER

- Click "Parent Directory" to return to the Road RAM website after downloading files.

MY *.KMZ FILE WAS SAVED AS A *.ZIP

- Certain web browsers automatically save *.kmz files as *.zip. However, only files with the KMZ extension can be uploaded to Road RAM website. In Windows Explorer, right click the file name. Select "Rename" and change the file extension from ".zip" to ".kmz".

DATABASE UPLOADS

I DO NOT SEE MY AREA OF INTEREST LISTED IN THE DROP DOWN MENU

- Only successfully uploaded STEP 1 areas of interest appear in the drop down menu. Repeat *Part I: Road RAM Protocols, STEP 1* as necessary to ensure proper upload to the database.
- Verify on the website banner that you are logged on as the correct user (see Figure 1.2). Data can only be viewed and accessed by the user who uploaded it.

MY *.CSV FILE WILL NOT UPLOAD

- There are several reasons why the database will not upload a *.csv file.
    - File has not been saved as a *.csv file. Open *.txt file in Excel and save as *.csv, not *.xls or *.xlsx.
    - Column headers do not match database tables. Both the order and name of column headers matter and data will not be imported if improperly formatted. See the *Part I: Road RAM Protocols* and website for visual guides.
    - Data type matters. Table 4.1 provides the type of data allowed for each field. Note: Numbers can be considered text, but letters can never be considered numbers.
    - The fields for several of the columns have specific rules associated with them: (1) Values must be unique (i.e., no two records can have the same value); (2) Fields must have information (i.e., no blank values in any of the highlighted fields in Table 4.1); or (3) Fields are restricted to specific values. Table 4.1 lists the rules for each field in the *.csv files associated with each STEP. Note: If there is an existing record in the database with the same unique value, the database record will be overwritten by the new data. See Figure 1.8 for the proper procedure for updating STEPs 1-4A data.
    - Several fields must be unique values. If two records in the same *.csv file have the same value, the file cannot be uploaded. This error is common for the STEP 3 *.csv file. Be sure to follow STEP 3 protocols to concatenate the "FID" and "Streetname" fields to create a unique value.
    - The STEP 4A "Name" must use the Road RAM user name as the prefix to the unique value in order to be properly uploaded to the Road RAM database. See STEP 4A protocols for details.

Table 4.1. Field types and value rules for *.csv files associated with Road RAM STEPs 1, 3, and 4A.

Road RAM STEP	Column Header	Field Type (units)	Unique Value?	Blanks Allowed?	Value Restrictions
STEP 1	FID_	Integer	No	Yes	n/a
	ID	Integer	No	Yes	n/a
	Area	Text	Yes	No	n/a
	AreaDesc	Text	No	Yes	n/a
	AreaArea	Double (ac)	No	No	>0
STEP 3	FID_	Integer	No	Yes	n/a
	RoadAA	Text	No	No	A; B; C
	RoadSE	Text	No	No	X; Y; Z
	RoadRSI	Integer	No	Yes	1; 3; 5
	RoadRisk	Text	No	Yes	PHR; PMR; PLR; SHR; SMR; SLR
	RoadClass	Text	No	No	AX; AY; AZ; BX; BY; BZ; CX; CY; CZ
	Name	Text	Yes	No	n/a
	RoadLength	Double (ft)	No	No	>0
STEP 4A	FID_	Integer	No	Yes	n/a
	Name	Text	Yes	No	n/a
	RSRisk	Text	No	Yes	PHR; PMR; PLR; SHR; SMR; SLR
	RSAA	Text	No	Yes[6]	A; B; C
	RSSE	Text	No	Yes[5]	X; Y; Z
	RSClass	Text	No	Yes[5]	AX; AY; AZ; BX; BY; BZ; CX; CY; CZ
	RSI	Integer	No	Yes	1; 3; 5

MY *.KMZ FILE WILL NOT UPLOAD

- There are several reasons why the database will not upload a *.kmz file.
    - For all STEPs, the *.csv file must be uploaded before the corresponding *.kmz file can be added. Ensure the *.csv file was uploaded properly.
    - For STEP 1, if the appropriate area of interest is not listed in the drop down menu, the STEP 1 *.csv file has not been uploaded successfully.
    - For STEPs 3 and 4A there must be a column in the attribute table called “Name” and this field must have the unique IDs corresponding to the Name field in the *.csv file. Ensure there is a “Name” table header. This can be verified by opening the *.kmz file in Google Earth. The “Name” field values will be listed next to the shape in Google Earth when you expand the fields (i.e., click the plus boxes to open all details). If there is no “Name” field or the values are not unique, the attribute table must be edited in ArcGIS. The “Name” field must also be designated as the Primary Display Field in the shapefile attribute table in GIS. See *Part III: GIS Commands* for details.
    - After clicking “*Process*” in STEP 3 kmz upload, wait for the following message to appear “*Your file upload was successful*.” Before closing your window follow the prompt to display upload streets on map by clicking the hyperlink “*Click this line to start than process*.”
    - Certain web browsers automatically save *.kmz files as *.zip. However, only files with the KMZ extension can be uploaded to Road RAM website. In Windows Explorer, right click the file name. Select “Rename” and change the file extension from “.zip” to “.kmz”.

[6] Blanks are allowed, unless STEP 3 has been completed and the user wants to spatially extrapolate data.

DATABASE FORMS

I DO NOT SEE MY ROAD SEGMENTS IN THE DROP DOWN LIST ON THE STEP 4B FORM

- Verify that the road segments have been successfully uploaded in STEP 4A.

COMMON ERROR MESSAGES

- Error: “The following fields are empty or invalid.” Do not hit “Enter” when inputting data into the fields on the form. Instead, use the “Tab” key or mouse to navigate between fields.
- “Road Segment ID”: You must select a road segment ID from the drop down list.
- “Total percent of MAC1 + MAC2 + MAC3 must equal 100%.”: The sum of the % of road segment for the heavy, moderate and light accumulation areas must be equal to 100.
- MAC # – Height: You must select a value for the Dust Test (e.g., Ankle, Knees or Waist) for any accumulation category where the percent is greater than 0 in row 3.
- MAC# – Feel: You must select a value for the Fines Test (e.g., Neither, Gritty, Slimy or Both) for any accumulation category where the percent is greater than 0 in row 3.

DATABASE MAPS

MY SPATIAL DATA IS NOT DISPLAYING CORRECTLY

- In order to rapidly display spatial data, the database generates multiple spatial files for each area of interest. These files are created as soon as the file is uploaded to the database, and then weekly updates are made. If data does not appear correctly, contact the Database Administrator for assistance.
- Verify the *.kmz files using Google Earth, outside of the database.
  - If data is presented properly in Google Earth, but not on the website, contact the Database Administrator for assistance.
  - If the data is not correct in Google Earth, re-export the file from GIS ensuring (1) that the layer is turned on in the table of contents and (2) that the Primary Display Field checkbox is checked for the appropriate field in the attribute table (see *Part III: GIS Commands).*
- The STEP 3 KMZ upload is a two-part process. After clicking “Process” on the upload page, the message “Your file upload was successful. A total of # records were added to ‘step3’ table. IMPORTANT: In order to display the streets you just uploaded, they must be created. This process could take from a few seconds to several minutes. Click this line to start that process.” You must click on the hyperlink to finish the process and correctly upload the roads to the database. If you did not do this, you must re-upload the STEP 3 KMZ file.

PART V: FIELD PROTOCOLS AND DATASHEET

Personnel Required:

1-2 Field Personnel 10-15 minutes per road segment.

Equipment Required:

Crediting Program
- **The Crediting Program recommends a minimum number of seasonal observation periods (see *Part II: Alignment with Crediting Program, page 2.2*).**

- 1'x'1 Square with Plastic Sheet
- Hand Broom
- Hard Edge
- Spray Bottle
- *Part V: Field Protocols and Datasheet*
- Camera
- Figures 1.21-1.24
- Calculator
- Duct Tape/Gorilla Tape
- Dustpan
- Wire Brush
- Funnel
- Paper Towels/Rags
- Pen
- 3 Graduated Cylinders (10ml, 100ml, 1000ml capacity)

Field personnel safety is of utmost importance. Use extreme caution when evaluating roads.

- Field personnel should first and foremost follow all jurisdiction-required safety protocols.
- Field vehicle should be parked completely on road shoulder, out of drive lane, and in area of high visibility.
- All field personnel should wear brightly colored safety vests.
- Establish a 'safety zone' with traffic cones.
    a. Place cones every 50-100 yards and extend a few feet into drive lane to create buffer for field personnel, while minimizing motorist disturbance and without forcing cars into oncoming traffic lane.
    b. Field personnel should set up all equipment within safety zone.
    c. Field personnel never stand outside of safety zone or between equipment and edge of safety zone.
    d. Unless absolutely necessary, do not stand/kneel with back to oncoming traffic.

TIMING OF FIELD OBSERVATIONS

Field observations on selected road segments may be conducted over multiple days, as long as no storm event requiring abrasive application or creating stormwater runoff occurs over the multi-day time span. Observations are grouped under a single observation period. The observation period is denoted by the first date and is formatted as YYYYMMDD (e.g., observation period "20101116" indicates the observations began November 16, 2010).

RULES
- **For best results, observations should be made when road surface is dry.**
- **When characterizing a road segment, walk the perimeter of the complete road segment and look at both road shoulders prior to completing measurements. Answers should be representative of the road segment as a whole.**
- **Enter all required information into field datasheet.**

ROAD SEGMENT METADATA (DATASHEET ROWS #1-2)

1. Arrive at specific road segment. Record RSID, date, time and personnel on datasheet (Row #1).
2. Define road segment area (10,000 ft^2 area) (Row #2). This step only needs to be completed during the first visit to a road segment.
    a. The width of the road segment is defined as the width between the two edges of continuous impervious area (Figure 1.21). Estimate average width of road segment by walking the width

Figure 1.21. Road Segment Width

from one edge of pavement to the other. Average human pace is 3 ft. Measure your pace prior to initiating STEP 4B and use your standard pace to estimate width. Additional impervious areas (bike lane, sidewalk, etc) that are beyond the right of way and are part of the continuous impervious surface from the center line must be included in the calculation of road segment width (Figure 1.22). For instance, if a lawn or pervious surface is located between the right of way and a sidewalk, the sidewalk is not included. Include all continuous impervious surfaces in road width, but do not add more than 20ft to the road segment width estimate for additional impervious area (see top of Figure 1.22B). Record the width of the road on field datasheet (Row #2).

b. To determine road segment length, divide 10,000ft^2 by the recorded width using a calculator. Record length (ft) on field datasheet (Row #2).

c. Record description of the physical features that designate the general start and end points of the road segment on field datasheet (Row #2). Each road segment should be generally identifiable based on field observations and photos so that a new team would be able to relocate the same road segment if desired.

MATERIAL ACCUMULATION AREAS (DATASHEET ROW #3)

> **Material Accumulation Areas are:**
> - **Unique to each road segment to represent relative heavy, moderate and light areas for specific segment.**
> - **Differentiated by both amount of material and visual assessments of material grain sizes.**

1. Categorize up to 3 accumulation categories for the road segment. **Material accumulation categories** are unique to each road segment. Each road segment can be categorized into no more than 3 material accumulation categories, designated heavy, moderate and light. Typically, a road segment will have 3 distinct material accumulation areas; however, dependant on recent climatic events and road maintenance activities, there may only be one or two distinct areas. Figure 1.22B provides schematics and photos of the general trends of winter material distribution on typical primary and secondary roads.

   a. Consider the entire road segment. Walk the entire perimeter of the road segment (both sides of the road) and inspect all potential condition indicators as you go to determine material accumulation areas.

   b. Identify the dirtiest (heavy) and cleanest (light) areas first, and then evaluate if there is an intermediate (moderate) designation.

   c. If two areas of a road segment visually appear to have the same amount of material on the road, but the dominant grain sizes between the two areas varies greatly, they should be designated as separate material accumulation categories. The area with the higher degree of fines should be designated as the dirtier area (e.g., heavy if considering heavy and moderate areas; moderate if considering moderate and light areas).

      - Differences in the amount of material on the road can be visually determined based on rough estimates of the percent coverage over the road surface, as well as the depth of the material on the road surface.
      - Differences in dominant grain size can be visually estimated. Can individual particles be distinguished? Do some locations appear to have larger grain sizes than other locations? Rub material between fingers: Does it feel gritty or smooth? Can you see your finger print? The use of visual observations detailed below can also be used to delineate area of accumulation.

   d. The user may perform field precision protocols when first using the Road RAM tool to calibrate their visual estimates with measured data.

Road segment facts

2 lanes of traffic

Parking on both sides

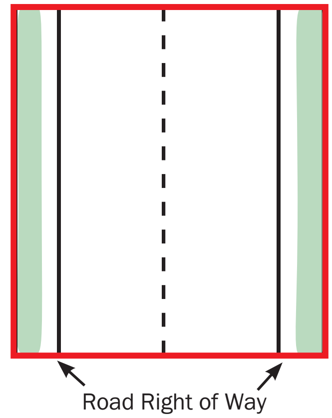
Road segment width

= 40 ft (~13 paces), then

Road segment length

= 250 ft (~83 paces)

Road segment features



Road segment facts

4 lanes of traffic

Parking on both sides

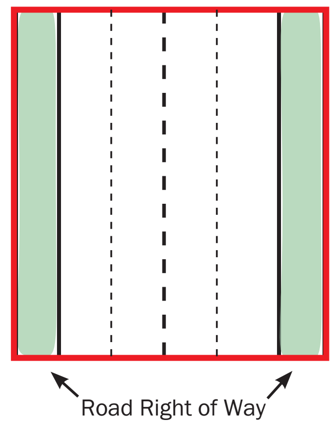
Road segment width

= 65 ft (~22 paces), then

Road segment length

= 150 ft (~50 paces)

Road segment features



Road segment facts

3 lanes of traffic

Bike lane on two sides

Sidewalk on one side

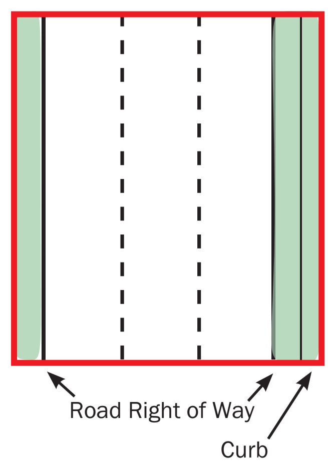
Road segment width

= 50 ft (~17 paces), then

Road segment length

= 200 ft (~67 paces)

Road segment features



These examples also include key road segment features.

LEGEND	
(red outline)	Road Segment (10,000 ft^2)
(green fill)	Added Impervious Area

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Road segment facts

3 lanes of traffic

Parking on two sides

Sidewalk on both sides

Additional impervious area >20ft (~7 paces); only add 20ft to estimated width

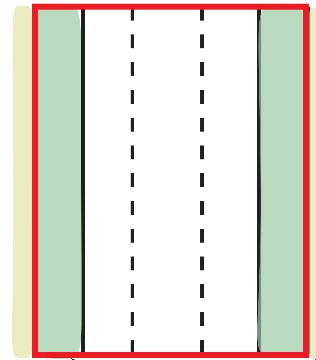
Road segment width

= 60 ft (~20 paces), then

Road segment length

= 165 ft (~55 paces)

Road segment features



Road segment facts

2 lanes of traffic

AC dike on both sides

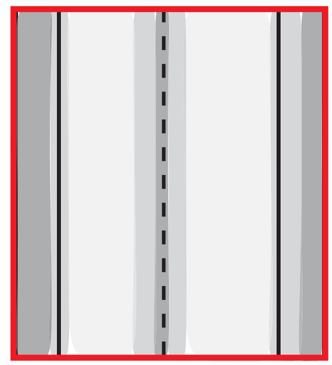
Road segment width

= 30 ft (~10 paces), then

Road segment length

= 330 ft (~110 paces)

Material accumulation distribution



Road segment facts

2 lanes of traffic

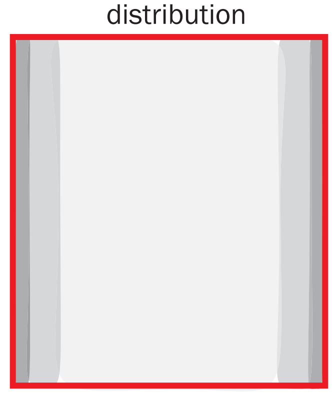
Road segment width

= 20 ft (~7 paces), then

Road segment length

= 500 ft (~167 paces)

Material accumulation distribution



These bottom 2 examples show the material accumulation distribution. See legend on Figure 24A for schematic shown with top photo.

LEGEND

Road Segment (10,000 ft^2)

Accumulation Category

Light | Moderate | Heavy

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ROAD SEGMENT EXAMPLES (PAGE 2 OF 2)

FIGURE 1.22B

2. Determine percent distribution of each categorized material accumulation area within the road segment based on the entire area of the road segment. Estimate approximate percentages across both the entire length and width of the road segment to determine overall road segment percentages. Include all contiguous impervious area, such as sidewalks, parking areas, etc., used to estimate road segment width. Where traffic conditions permit, field personnel should pace the width of each accumulation category to determine relative areal distribution percentages. For example, if the road segment width is equal to 12 paces, and the paces for the heavy, moderate and light areas are 2, 4 and 6 respectively, the percent distribution would be equal to 17% heavy, 33% moderate, and 50% light.
3. Record percent distribution of each area on field datasheet in 5% increments. In the example above, the user inputs would be 20% heavy, 30% moderate, and 50% light. If the area is absent from the road segment, enter 0.

DRY MATERIAL COLLECTION PER MATERIAL ACCUMULATION AREA (DATASHEET ROWS #4-6)

The road segment score will inherently be most sensitive to the observation results from the areas that represent the majority of the road segment. The most care should be taken to obtain accurate observations in areas that represent 50% or more of the road segment.

When selecting 1'x1' squares:
- **Field personnel safety is the highest priority. Do not make observations within the flow of traffic.**
- **Material distribution will not be uniform – choose a location that appears to be average in terms of amount of material and grain size distribution.**

6. Choose a representative location in the heavy area for volume measurements and degree of fines observations. The user may perform field precision protocols when first using the Road RAM tool to calibrate their visual estimates with measured data.
7. **Collect dry sample**.
   a. Place 1x1 frame on road surface, ensuring frame maintains square shape.
   b. Use wire brush/toothbrush to dislodge and fine material caked on the road surface.
   c. Use hand broom to sweep all material into dust pan.
      - For road surfaces with poor integrity (i.e., high distribution of cracks and crevices), mine all cracks to extract as much material from road surface within square as possible.
      - Stormwater is very efficient at removing material from road – field personnel must be diligent to remove all available material.
   d. Remove large pieces of organic material (e.g., pine needles, leaves, etc.) from dust pan.
   e. Transfer sample from dust pan to appropriately-sized graduated cylinder using funnel.
   f. Measure volume and select appropriate value range (ml) on field datasheet. Volume should be measured to closest demarcation on the graduated cylinder.

When measuring dry sample:
- **Volume ranges are provided on the field datasheet. Field measurements need to be as precise as the ranges indicate.**
- **The detection limit for dry sample measurements is 0.2 ml. If no material is visible, select 0 on the field datasheet.**

8. **Perform Fines Test** (Figure 1.23).
   a. Locate representative area within the heavy material accumulation area. It should not be the same area where dry sample was collected.
   b. Scrape road surface with a hard edge, using moderate amount of pressure to remove top layer of coarser material from surface.
   c. Ensure fingers are clean prior to performing test. Wet fingers using spray bottle.

NO MATERIAL visible.

YES finger prints visible; SLIMY fingers.

YES finger prints visible; GRITTY fingers.

YES finger prints visible; BOTH gritty and slimy fingers.

NO finger prints visible; BOTH gritty and slimy fingers.

NO finger prints visible; SLIMY fingers.

NO finger prints visible; SLIMY fingers.

Note: Proper technique requires user to rub the finger pads of at least two fingers back and forth across road surface at least 3 times.

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FINES TEST EXAMPLE

FIGURE 1.23

d. Using two fingers and a moderate to high amount of pressure, rub the pad of the fingers back and forth along 6” (approximately the length of a hand) of the road surface at least 2 times (e.g., cover 24”) of road surface.
e. Look at finger surface. Is there material present on fingers? If no material can be seen, record “No Mat’l” on datasheet. If material is present, are fingerprints visible through the material on finger? Record answer (Yes/No) on field datasheet (see Figure 1.23 for photo examples).
f. If material is present on fingers, wet fingers with spray bottle and rub together. Do fingers feel slimy and/or gritty? Record answer (Gritty/Both/Slimy) on field datasheet (see Figure 1.23 for photo examples).

When conducting Fines Test:
- **The greater the amount of fine material on the road surface, the higher the likelihood your fingerprints will be covered and not visible.**
- **Fines are clay-sized particles and in high concentrations will put a slimy film on your finger.**
- **Larger grain sizes are coarser and will feel gritty when your fingers are rubbed together.**

9. **Perform Dust Test** (Figure 1.24).
a. Within unswept 1x1 foot square within the heavy material accumulation area, sweep road surface vigorously (5 sweeps in 3 seconds).
b. Within 2 seconds of sweeping, estimate the height of the resulting dust cloud. If no dust cloud is visible, record “No Cloud”. Height is estimated based on the body parts of the sweeper. It is easiest if one person sweeps, and the other field personnel records observations. Record height (Ankle/Knee/Waist) on field datasheet (see Figure 1.24 for photo examples).
c. Estimate duration of time (in seconds) the dust cloud is visible. Record as either less than or greater than 2 seconds on field datasheet (see Figure 1.24 for photo examples).

When conducting Dust Test:
- **The greater the amount of fine material on the road surface, the larger the resulting dust plume will be and the longer it will remain suspended in the air.**

d. Note: In windy conditions (>10 mph) this observation will be difficult. If dust test cannot be accurately performed, evaluate the air quality conditions due to wind. If no dust is visible in air, enter “No Cloud”. If a few particles of dust are visible, enter “Ankle” and “> 2 seconds”. If a moderate amount of dust is visible, enter “Knee” and “>2 seconds”. If heavy dust is visible (i.e., you can feel it in your eyes and nose), enter “Waist” and “>2 seconds”.

10. Repeat above dry material protocols in the moderate and light material accumulation areas on road segment, as necessary, and record answers and measured volumes on the field datasheet (Datasheet Rows #5 and #6). For each road segment, 3 dry material sample collections, 3 fines tests, and 3 dust tests are conducted, unless a material accumulation category is absent (0% distribution in Datasheet Row #3).

ANKLE high; > 2 seconds in air

WAIST high; > 2 seconds in air

Note: Proper technique requires user to sweep 1'x1' square area briskly (3 times in 5 seconds) and immediately measure height of resulting dust cloud and time dust remains suspended.

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DUST TEST EXAMPLES

FIGURE 1.24

ROAD RAM STEP 4B FIELD OBSERVATIONS FIELD DATASHEET

Row #	**ROAD RAM STEP 4 Field Observation Datasheet**				
1	RS ID	Field Personnel	Observation Date		
Road Segment (RS)					
2	Estimated Width (ft)	Length (ft) [10,000/Width]	RS Start		RS End
Percent Distribution Material Accumulation Area					
3		Heavy	Moderate		Light
	% of Road Segment				
Dry Material Collection					
HEAVY MATERIAL ACCUMULATION AREA					
4	**Volume (ml)**	**Fines Test**	**Dust Test**		
	0 0 - 1 1 - 5 5 - 10 10 - 30 30 - 100 > 100	Finger print visible? No Material Yes No	Height	No Cloud Ankle Knee Waist	
		Gritty / Both / Slimy	Seconds	< 2 seconds >2 seconds	
MODERATE MATERIAL ACCUMULATION AREA					
5	**Volume (ml)**	**Fines Test**	**Dust Test**		
	0 0 - 1 1 - 5 5 - 10 10 - 30 30 - 100 > 100	Finger print visible? No Material Yes No	Height	No Cloud Ankle Knee Waist	
		Gritty / Both / Slimy	Seconds	< 2 seconds >2 seconds	
LIGHT MATERIAL ACCUMULATION AREA					
6	**Volume (ml)**	**Fines Test**	**Dust Test**		
	0 0 - 1 1 - 5 5 - 10 10 - 30 30 - 100 > 100	Finger print visible? No Material Yes No	Height	No Cloud Ankle Knee Waist	
		Gritty / Both / Slimy	Seconds	< 2 seconds >2 seconds	

PART VI: ACRONYMS AND GLOSSARY

LIST OF ACRONYMS

A&T Tool	TMDL Accounting & Tracking Tool
BMP RAM	Best Management Practice Maintenance Rapid Assessment Methodology
CRC	Characteristic Runoff Concentration
Crediting Program	Lake Tahoe Clarity Crediting Program
DCIA	Directly Connected Impervious Area
EMC	Event Mean Concentration
FSP	Fine Sediment Particles (<16µm)
LRWQCB	Lahontan Regional Water Quality Control Board
NDEP	Nevada Division of Environmental Protection
PLRM	Pollutant Load Reduction Model
RAM	Rapid Assessment Methodology
Road RAM	Road Rapid Assessment Methodology
SD	Standard Deviation
TMDL	Total Maximum Daily Load
WQIP	Water Quality Improvement Project

GLOSSARY

Abrasive Application Priority	The relative frequency and rate at which road abrasives are applied during winter storm and freezing conditions. Roads are designated as intensive, moderate, or rarely to never, where "intensive" roads receive the greatest annual mass per unit length of road abrasives during the year, and "rarely to never" roads receive the least.
Best Management Practices Maintenance Rapid Assessment Methodology (BMP RAM)	The BMP RAM was the first customized urban RAM tool developed for the Tahoe Basin stormwater community. The BMP RAM is a simple and repeatable field observation and data management tool to assist Lake Tahoe natural resource managers in determining the relative condition of an urban stormwater Treatment BMP. The tool consists of six distinct BMP RAM STEPs implemented by the user and a supporting database.
Calibration Year	Road RAM application to the Crediting Program. During the first year an urban jurisdiction is using the Road RAM and every fifth year thereafter the jurisdiction is expected to conduct a large number of Road RAM observations performed at many different times throughout the year in order to calibrate the jurisdictional road class categories. The purpose of calibration is to increase confidence in the spatial extrapolation techniques used during the check up years.

Characteristic Runoff Concentration (CRC)	A representative concentration for a pollutant of concern in stormwater runoff from a specific urban land use and its associated condition.
Check up Year	Road RAM application to the Crediting Program. Once a jurisdiction's implementation plans and operational activities are calibrated with Road RAM scores during a calibration year, a reduced number of observations focused on the most critical times of the year is sufficient to ensure that maintenance plans are being implemented effectively. Moderate statistical variability is acceptable during check-up years, but high variability is potentially an indication of a performance problem that should be investigated and addressed.
Directly Connected Impervious Area (DCIA)	See Road Shoulder Connectivity.
Field Observations (Road RAM STEP 4B)	A compilation of distinct rapid observations and/or measurements made at road segments over time to evaluate and track condition.
Fine Sediment Particles (FSP)	FSP refers to the mass fraction of the TSS (total suspended sediment) concentration that consists of particles 16µm or smaller, expressed as a % TSS by mass and allowing a concentration of FSP to be simply calculated.
Inventory (Road RAM STEP 2)	The user employs the provided Tahoe Basin road layer for the inventory of the roads within the designated area of interest. The user may also spatially map a variety of road attributes of the roads as desired using GIS and field mapping to later analyze road RAM scores relative to road attributes of interest.
Material Accumulation Category	Roads have a typical pattern of heavy, moderate and light material accumulation as a result of transport and sorting by vehicle traffic and wind. The distribution of material accumulation is unique to each distinct road segment and the categories are relative to one another for the specific day of observation.
Observation Period	The discrete period of time when Road RAM field observations are conducted to determine road condition and calculate Road RAM scores. If the area of interest is relatively large and requires a number of consecutive days to obtain results, all observations are lumped into one observation period and documented as the date of the first day Road RAM observations were initiated. Ideally neither road maintenance practices (e.g., sweeping or abrasive application) nor a stormwater runoff event occur during an observation period.
Pollutant Load Reduction Model (PLRM)	PLRM is a custom desktop stormwater model developed for Tahoe Basin stormwater managers to estimate the pollutant load reductions associated with catchment-scale water quality improvement actions. The PLRM Road Methodology was developed to predict the likely annual road condition and associated characteristic runoff concentrations (CRCs) for the pollutants of concern by integrating road risk with general water quality improvement practices implemented by road risk category (nhc et al. 2009a).

PLRM Road Risk

A road attribute that incorporates road characteristics assumed to impact the relative risk of pollutant generation and transport downslope. Road risk is based on slope, traffic density, and adjacent land use, which are thought to influence the road's potential sources and transport capacity. A default road risk GIS layer has been created for the Tahoe Basin and is used in PLRM (nhc et al. 2009a).

Pollutants of Concern

The pollutants identified to have the greatest impact on the receiving waters' beneficial uses. In the case of Lake Tahoe, the continued decline in lake clarity is attributed to both the increased loading in fine sediment particles (FSP; <16µm in diameter) and algae production. Therefore the identified pollutants of concern are FSP and biologically available nutrient species: nitrate-nitrite (NO_x) and soluble reactive phosphorous (SRP).

Road Attribute

Any trait of a road network that can be spatially mapped and is expected to vary across an area of interest. Examples of road attributes include road shoulder condition, road shoulder connectivity, road surface integrity, road type, PLRM road risk, etc. The specific categorical designations within each attribute are called road attribute categories. Typically there are three to four categories associated with an attribute, defining the relative high and low bookend values and allowing for intermediate values. Depending on the road attribute, categories can be defined in absolute terms (e.g., PLRM road risk, road shoulder condition) or in relative terms (e.g, high, moderate and low sweeping priority). Road attributes of interest are inventoried by the user during Road RAM STEP 2 as desired. Road attributes can be overlain with Road RAM scores during STEP 6 to allow visual comparisons of attributes and road condition and inform maintenance actions or strategies, road improvement projects (e.g., resurfacing), water quality improvement projects, etc.

Road Class

Nine road classes are defined based on the combination of pollutant control practices employed on a particular road throughout the year, including the relative planned abrasive application priority during winter road conditions and relative planned sweeping priority when the weather is favorable for pollutant recovery. Road class is used to spatially extrapolate road segment scores to a greater area of roads to calculate Road RAM scores. The jurisdictions classify the roads in their jurisdiction based on actual maintenance practices during STEP 3.

Road Condition

The relative risk to downslope water quality from a road at the time of observations, quantitatively expressed as a Road RAM score. The primary pollutant of concern is fine sediment particles (FSP < 16µm), but total suspended sediment and nutrient species are also assumed to vary in relative magnitude with road condition. The condition of a road fluctuates over time due to the continual balance of pollutant sources and sinks based on a variety of factors, primarily physiographic characteristics and associated road maintenance practices. The Road RAM tool provides a quantitative measure of road condition on a 0-5 scale, with 5 being the best possible condition, with very low water quality risk downslope.

Road RAM

A simple and repeatable field observation and data management tool to assist Tahoe Basin natural resource managers in determining the relative condition and relative maintenance urgency of roads for water quality. The tool consists of six distinct RAM STEPs implemented by the user and the corresponding information stored in a custom *database*. Road RAM quantifies road condition for specific road segments using the Road RAM field protocols at a discrete point in time and spatially extrapolates the results to all of the roads within the subject area of interest. Road RAM results can be temporally extrapolated for comparison to expected annual road conditions.

Road RAM Database (database)	Version 1 of the database is an online database (www.tahoeroadram.com) with Google® Maps display that stores and manages all information necessary to implement, track and maintain Road RAM data and results over time. The Road RAM user generates data and/or information from GIS or field observations and enters it into the database.
Road RAM Score	A value between 0 and 5 that represents the temporally-discrete, spatially-extrapolated road condition as a result of Road RAM field observations conducted at one or more road segments. The Road RAM score is an average of road segment scores for roads of the same road class. A Road RAM score of 5 is the achievable score that results in a minimal downslope impact to water quality during a subsequent runoff event. The Road RAM score declines as the relative amount of available fine sediment particles present on the road segment increases, thus increasing the risk to downslope water quality should a runoff event occur.
Road Segment (Road RAM STEP 4A)	A 10,000 ft^2 road unit is the standardized road area evaluated by the user using the Road RAM field protocols during STEP 4. This size is assumed to be large enough to be representative of a road, while small enough that the road condition can be assessed rapidly (less than 10 minutes).
Road Segment Score	A value between 0 and 5 obtained from Road RAM field observations at one point in time for a 10,000 sq ft road unit. Road segment scores are obtained from a number of road segments belonging to the same road class. They are averaged to determine a Road RAM score for that road class.
Road Shoulder Condition	A road attribute defined by PLRM (nhc et al 2009a) to characterize the source control efforts to reduce road shoulder and primary flow path erosion along the side of the roadway. The road shoulder can be one of 4 conditions: erodible (neither protected nor stable), protected, stable or stable and protected. See Section 10.2 for summary of how road shoulder condition is determined for a specific road segment.
Road Shoulder Connectivity	A road attribute which defines the degree of hydraulic connection between the road surface and a surface water resource. Impervious area connectivity is defined using the following two terms: Directly Connected Impervious Area (DCIA) – impervious surfaces draining through a hydraulic connection (water flow is continuous) to a surface water drainage system. Where a surface water drainage system could be storm drain, a stream channel, a storm water treatment facility, or any receiving water. Indirectly Connected Impervious Area (ICIA) – impervious surfaces draining to pervious surfaces that promote sheet flow, infiltration, or storage prior to overflow discharging to a surface water drainage system.
Road Surface Integrity	A road attribute that defines the quality of the surface of the road segment. Asphalt integrity declines over time as a result of traffic wear, freeze/thaw cycles and other factors. Road observations in Tahoe Basin indicate that the relative distribution and severity of asphalt cracking and fissures can influence the road condition as a result of the storage of material within the cracks that may not be effectively recovered from sweepers.

Sweeping Effectiveness	Sweeping effectiveness is relative ability to remove material from the road surface and improve road condition. Sweeping effectiveness is the combined implementation of sweeper type and frequency of sweeping. Sweeper types range from mechanical brooms that are not effective as removing small particulate material to vacuum-assisted units that have a relatively more effective at removing smaller particles from a road surface. Frequency of sweeping is a key component of effectiveness to improve road condition, as single and/or infrequent sweeping does not have the same ability to maintain road condition as more frequent efforts. See PLRM Development Document (nhc et al. 2009b) and Section 5.3 for more information.
Sweeper Type	A wide range of models and types of road sweeper types exist. Consistent with PLRM (nhc et al 2009a), Road RAM categorizes sweepers into 4 distinct types: mechanical broom, tandem operation (mechanical + vacuum assisted), regenerative air (dustless) and high efficiency vacuum assisted (dustless). The sweeper types are listed in increasing order of pollutant removal efficiency based on existing sweeper effectiveness research and summarized in nhc et al (2009b).
Threshold Value	A Road RAM score of 2 is identified as the threshold value, below which there is high confidence that the road is an immediate risk to downslope water quality. A Road RAM score of 2 equates to a predicted FSP concentration of 291 mg/L generated from the road segment based on existing data (2NDNATURE and nhc 2010a, 2010b).
Total Suspended Sediment (TSS)	TSS is the mass of sediment contained in a known volume of water, and stormwater samples analyzed for TSS can be used to quantify the suspended sediment loads transported in runoff.

APPENDIX A: TEST ROAD RAM IN WASHOE COUNTY CATCHMENT

2NDNATURE tested and refined Road RAM protocols on an urban catchment in Incline Village, Washoe County, NV (Area= UPC_WC1). Road RAM STEPs 1-3 data was obtained and mapped by 2NDNATURE in Summer 2010 with assistance from Washoe County personnel. Hypothetical Road RAM STEP 4 data was generated for illustrative purposes only to demonstrate the functionality and analysis power of the Road RAM tool and to create a hypothetical Road RAM dataset. The data presented in Appendix A do not represent actual road conditions in UPC_WC1. Below is a summary of the source of information and data used to complete each step and create the example products presented as screenshots from the Road RAM database.

A complete Road RAM training exercise has been developed using the UPC_WC1 data for new users to provide an introduction to the Road RAM tool. Go to www.tahoeroadram.com under “Downloads” -> “Road RAM Training Exercise” to obtain the training materials. Follow the instructions within RoadRAMTrainingExercise.pdf to log in and experiment with the Road RAM tool with pre-populated data. All necessary information is available on the website.

STEP 1 – Define AREA of Interest. 2NDNATURE utilized urban planning catchment shapefiles and contours provided by Washoe County to delineate and define the area of interest (Area= UPC_WC1; Figure A.1).

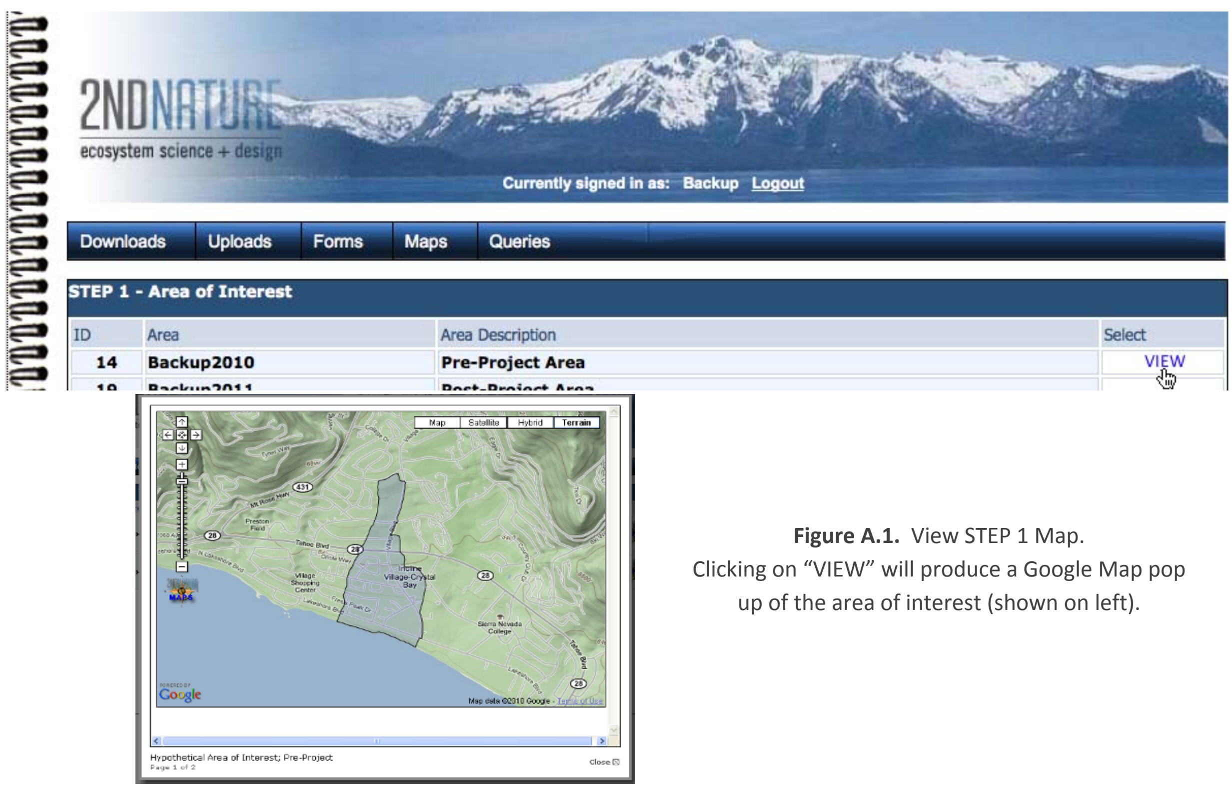

Figure A.1. View STEP 1 Map.
Clicking on “VIEW” will produce a Google Map pop up of the area of interest (shown on left).

STEP 2- Create INVENTORY of Road Attributes. 2NDNATURE created a road inventory of available road attributes for UPC_WC1. Road risk data was derived from the existing PLRM road risk layer (Fall 2010). 2NDNATURE mapped road surface integrity, road shoulder condition, and road shoulder connectivity in the field (Summer 2010). The outputs of STEP 2 are mapped road attributes and road risk is presented as a sample below (Figure A.2).

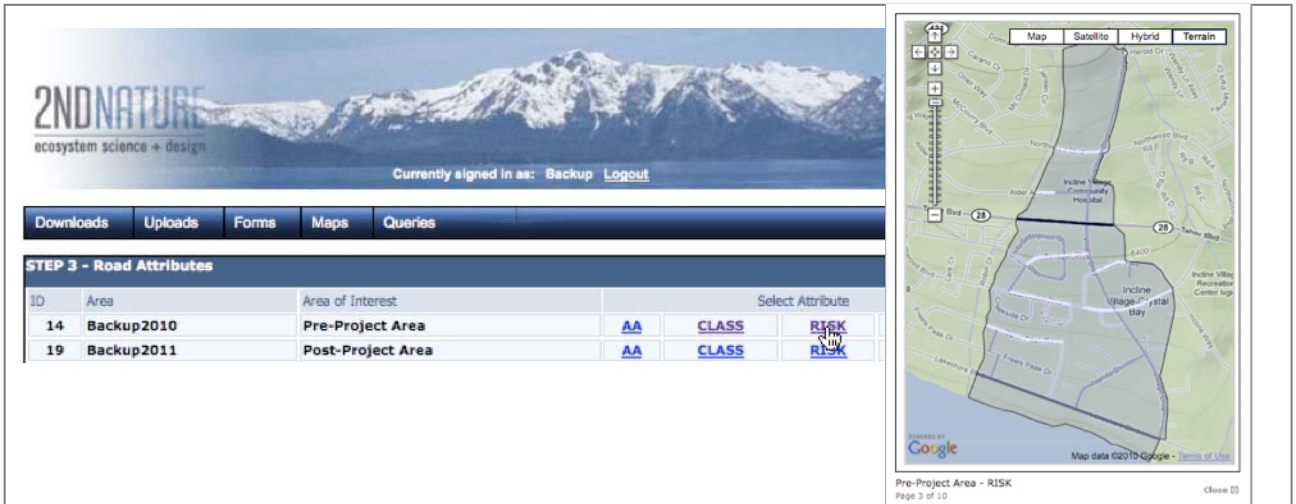

Figure A.2. View road attributes mapped in GIS and uploaded to the database. Selecting a road attribute, in this example, RISK, will produce a Google Map pop up of the area of interest (shown on right).

STEP 3 – CLASSIFY Roads. In collaboration with Washoe County stormwater manager and public works personnel, 2NDNATURE created maps of relative abrasive application priority and relative sweeping effectiveness. These road attributes were intersected in ArcGIS to create road class for UPC_WC1 and uploaded to the database (Figure A.3).

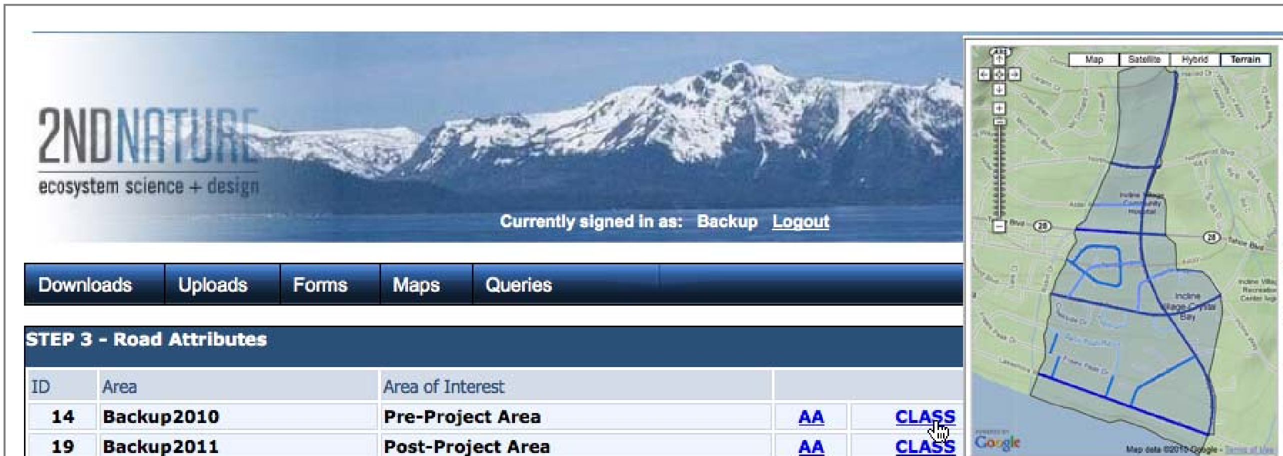

Figure A.3. View STEP 3 Map. Selecting a road attribute, in this example, CLASS, will produce a Google Map pop up of the area of interest (shown on right).

STEP 4A – Select ROAD SEGMENTS. 2NDNATURE selected a series of hypothetical road segments for Road RAM field observations based on the distribution of road class within the area of interest. Each road segment was assigned a unique ID and spatially identified on the screenshot below (Figure A.4).

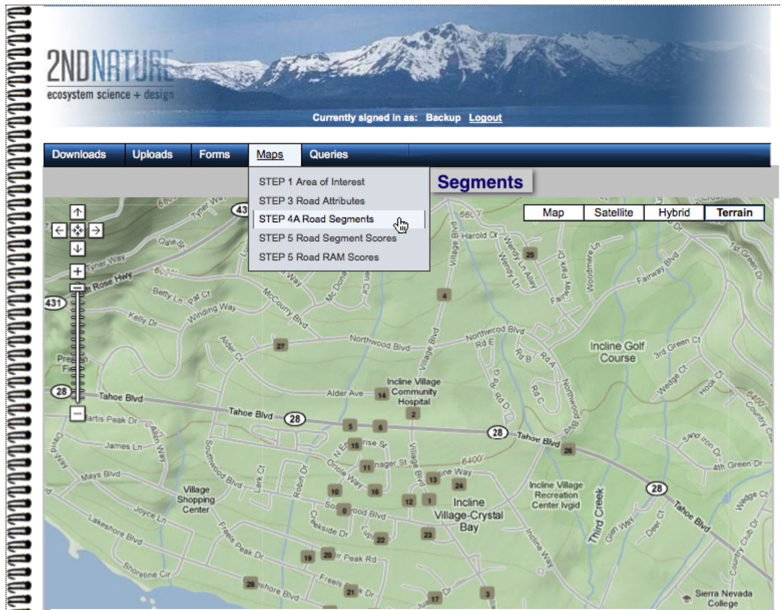

Figure A.4. View STEP 4A Map.

STEP 4B – Conduct FIELD OBSEVATIONS. For illustrative purposes only, 2NDNATURE generated hypothetical data for all of the road segments on 9/21/10. Screen shot of a completed road segment field evaluation is provided below (FigureA.5).

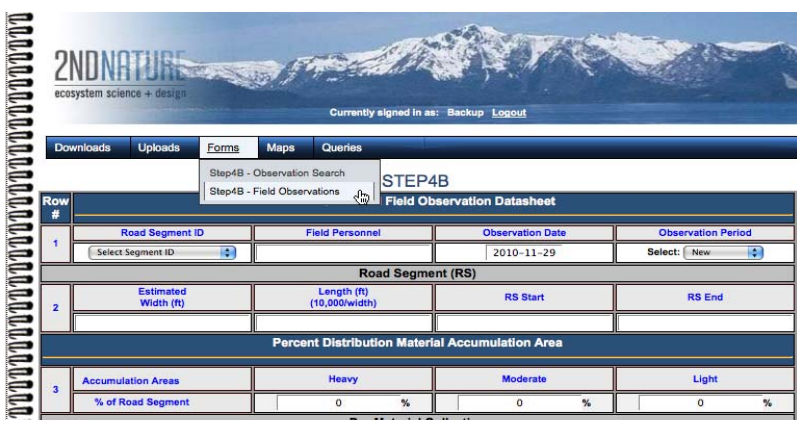

Figure A.5. STEP 4B Data Entry Form.

STEP 5 – Obtain Road RAM SCORE. The hypothetical road segment scores (Figure A.6) are integrated by Road Class and used to generate Road RAM scores for UPC_WC1 on 4/22/10 (Figure A.7). These results are hypothetical and do not represent actual Road RAM data.

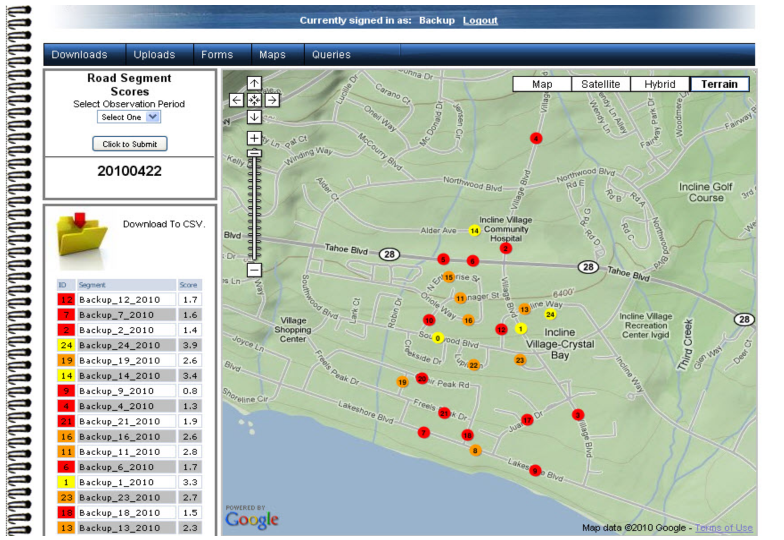

Figure A.6. STEP 5 Road Segment Score Map.

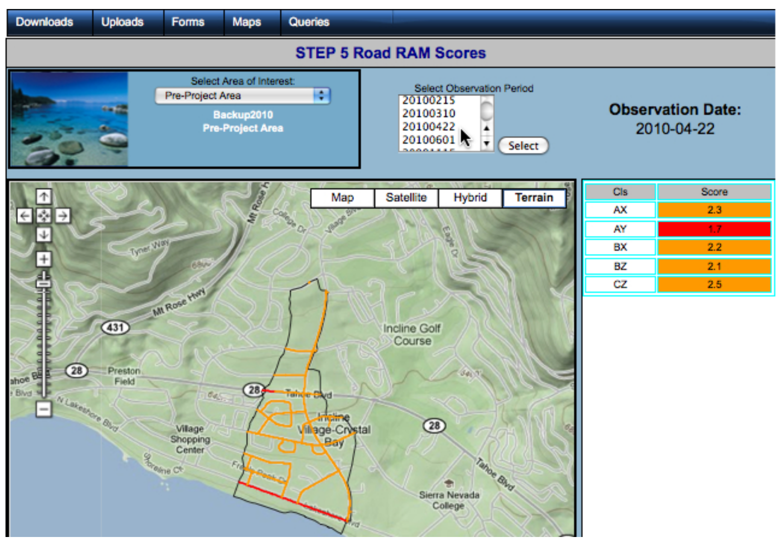

Figure A.7. STEP 5 Road RAM Score Map.

STEP 6 – ANALYZE Results. The hypothetical data can also be used to answer a number of questions regarding road condition in UPC_WC1. Roads with RAM scores below 2.5 may be targeted by the maintenance crew to explore improvements to road maintenance practices to protect water quality. Or road segment selection can be used to evaluate if roads with poor road surface integrity tend to have lower road segment scores, due to the limited ability of sweepers to recover material in road surface cracks. The road segment scores and Road RAM scores can be overlain with other road attribute layers (such as road surface integrity) to investigate how road conditions vary across roads and over time. Data can be interpreted spatially using the database or GIS or datasets can be exported from the database in tabular format for further analysis. See *Road RAM Technical Document Chapter 10: Application of Road RAM Data and Results* for more data analysis approaches.